Organization of agricultural production
a contract theoretical approach

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ORGANIZATION OF AGRICULTURAL PRODUCTION
- A CONTRACT THEORETICAL APPROACH

Ph.D. Thesis
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Preface

The organization of agricultural production is rapidly changing. The vertical coordination is increasing, so that fewer and fewer products are traded on open markets. Production contracts play an important role in this process. In this thesis a number of economic issues related to this development are addressed. The thesis consists of five parts that can be read independently.

This Ph.D. thesis concludes four years of graduate studies (the 4+4 program) at The Royal Veterinary and Agricultural University, Copenhagen. During my Ph.D. program I have spend one year at the University of California, Davis.

Discussions with colleagues, students, and contacts in the food industry have contributed to the ideas of this thesis. Especially, I would like to thank my supervisor professor Peter Bogetoft for very fruitful and inspiring cooperation.

I would also like to thank participants at seminars at The Royal Veterinary and Agricultural University (Copenhagen), North Carolina State University, University of California, Davis, Agricultural University of Norway, and Swedish University of Agriculture Sciences for helpful comments.

As part of my Ph.D. program I have participated in the project "Economic Analysis of Danish Agricultural Contracts". Part 5 of this thesis is based on this project. The aim of the project was to combine the knowledge from contract theory with experiences from the practice of contracting. Therefore, the project has been based on a close contact to the food industry. The interaction between researchers and the food industry has been particularly inspiring for my research. I am grateful for the support offered by the Norma and Frode S. Jacobsen Trust for the project, which made it possible to organize an international workshop on Danish agricultural contracts, and to employ three research assistants. The research assistants, Henriette Broman, Pia Sebelin Skogø and Frederik Rygaard Svare, have been responsible for much of the contact to the food industry. I would like to thank the research assistants for inspiring discussions and their helpfulness throughout the project.

At the personal level I would like to thank Pia for valuable support and encouragement throughout the entire Ph.D. program.

The Ph.D. thesis was successfully defended on May 31st 2002. This book contains a revised version of my Ph.D. thesis where some minor typos have been corrected. There have been no changes in the content.

Copenhagen, September 2002

Henrik Ballebye Olesen

Resume

This section gives a short summary of the thesis in Danish. For an English summary of the thesis, please see part 1 of the thesis.

Denne Ph.D.-afhandling har både en teoretisk og en erhvervsmæssig baggrund. Den teoretiske baggrund er udviklingen af den økonomiske kontraktteori gennem de seneste årtier. Den erhvervsmæssige baggrund er de seneste års udvikling i landbruget i retning af øget vertikal koordination – bl.a. ved hjælp af kontraktproduktion.

Afhandlingen består af fem dele. Del 1 giver et sammendrag af afhandlingen. De øvrige fire dele af afhandlingen falder i to hovedgrupper. Første hovedgruppe (del 2-4) består af artikler med teoretiske bidrag til den kontraktteoretiske litteratur. Anden hovedgruppe er en bog om design af produktionskontrakter. I denne bog anvendes kontraktteorien til analysere en række konkrete kontrakter mellem landmænd og forarbejdningsvirksomheder.

Anden del, artiklen "Incentives, Information Systems and Competition", analyserer hvordan muligheden for at anvende støjbehæftet information (signaler) i incitamentskontrakter afhænger af konkurrenceforholdene. I en verden med én principal og én agent er alle signaler værdifulde, så længe de blot er en smule informative. Dette ændres markant, hvis der er konkurrence mellem flere principaler og mellem flere agenter. Konkurrence reducerer værdien af støjfuld information, fordi konkurrence begrænser mulighederne for at benytte stærke incitamenter. Årsagen er at konkurrence tvinger principalerne til at betale den forventede værdi af et produkt, givet produktets signal. Prisen på et produkt karakteriseret som høj kvalitet skal således tage højde for at produkter med lav kvalitet fejlagtigt kan blive karakteriseret som værende høj kvalitet og omvendt. Det betyder, at det ud fra et samfundsøkonomisk perspektiv kan være fordelagtigt at begrænse konkurrencen, fx gennem vertikal eller horisontal integration.

Tredje del af afhandlingen, artiklen "Discrimination and Group Division in Tournaments", analyserer vekselvirkningen mellem moral hazard, risikodeling og diskriminering i kontrakter baseret på relativ præstationsevaluering (turneringer). Artiklen beskæftiger sig med en situation, hvor en principal er tvunget til at benytte samme kontrakt til alle agenter, selvom disse er heterogene i to dimensioner: produktionsmuligheder og alternative indtjeningsmuligheder. Artiklen viser, hvordan principalen kan forbedre sin profit ved at forvride incitamenterne (til skade for moral hazard problemet og risikodelingen, men til gavn for diskrimineringen). Principalen kan også forbedre sin profit ved at opdele agenterne i en række mindre grupper.

Fjerde del af afhandlingen, artiklen "Single Bid Restriction in Milk Quota Exchanges – Comparing the Danish and the Ontario Exchanges" analyserer auktionsreglerne på den danske mælkekvotebørs. Her må en producent må kun indlevere ét købsbud. Dette skaber inefficiens af to årsager. For det første kan en produ-

cent ikke afspejle en faldende efterspørgselskurve vha. et enkelt bud, hvilket skaber en aggregeringsfejl. For det andet beskytter købere sig mod risikoen for at miste en profitabel handel ved at byde deres gennemsnitsværdi af kvote i stedet for marginalværdien af kvote. Vi benytter data fra mælkekvotebørsen i Ontario til at beregne den empiriske betydning af at give producenter mulighed for at afgive flere bud på mælkekvotebørsen.

Femte del af afhandlingen består af bogen ”Design of Production Contracts: Lessons from Theory and Danish Agriculture”. Bogens kapitel 1 beskriver baggrunden for projektet. Bogens kapitel 2 sammenfatter hovedbudskaberne fra den kontraktteoretiske litteratur og fra erfaringerne med kontraktproduktion i dansk landbrug. Der opstilles en checkliste for design af produktionskontrakter med 10 punkter. Kapitel 3 beskriver kontraktteorien ud fra en holistisk tilgang. Der opstilles et målhierarki over de elementer af kontraktteorien, som er særligt relevante i kontrakter mellem landmænd og forarbejdningsvirksomheder. Målhierarkiet er baseret på tre centrale problemer i kontraktdesign: koordination, motivation og transaktionsomkostninger. Kapitel 4 analyserer kontrakten mellem ærteproducenter og Danisco Foods. Kontrakten er baseret på et turneringssystem. Kontrakten analyseres ud fra generelle problemstillinger såsom koordination, risikodeling, motivation og diskriminering. I kapitel 5 analyseres de kontrakter der benyttes af andelsselskabet Danish Crown i produktionen af specialsvin. Danish Crown gør brug dels af faste tillæg, dels af markeds-bestemte tillæg til specialproducenterne. De markedsbestemte tillæg afhænger af, hvor stor en andel af specialproduktionen, der faktisk sælges som specialsvin (og ikke som standardsvin). De to systemer giver anledning til forskellige konflikter mellem de traditionelle producenter og specialproducenterne i Danish Crown. Endelig indeholder bogen 8 faktablade, som beskriver konkrete kontraktforhold ud fra produktionsbetingelser, ejerstruktur og de vigtigste elementer i kontrakterne.

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Organization of Agricultural Production
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Part 1.

Summary:
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1 Abstract

This paper summarizes the theoretical and industrial background for my Ph.D. thesis. The paper also provides a brief overview of the papers in the thesis. My work falls into two categories: (1) theoretical papers based on stylized models and (2) contract theory applied to specific contracts.

2 Background

This Ph.D. thesis has both a theoretical and an industrial background. The theoretical background is the developments of contract theory in recent decades. The industrial background is the recent development of agricultural production and supply chains towards increasing vertical coordination.

2.1 Theoretical Background

Coase made the first economic analysis of different organizational forms in 1937. However the literature on the economics of organizations did not develop much until the 1970s. Over the last 25-30 years there has been a huge development of organizational economics. Contract theory is one branch of this literature. Contract theory focuses on how formal and informal agreements between independent parties can generate economic benefits.

According to Coase, a firm will undertake those activities for which the sum of production- and transaction costs incurred in in-house production is less than the sum of production- and transaction costs incurred through market transactions.

However, the internal and market transactions only represent the poles of organizational forms. There are a number of hybrid organizational forms, such as

- *Spot market*: the transaction occurs in the market, but there is no long-term commitment.
- *Contract production*: no market transaction, the contracts tie the parties together for a certain time.
- *Producer cooperatives*: internal transactions, the producers are partly autonomous.
- *Vertical integration*: only internal transactions, the parties are tied together through common ownership and management.

Contract theory focuses on how formal and informal agreements between independent parties can generate economic benefits in different organizational forms. Contract theory covers all the organizational forms mentioned above. The toolbox of contract theory contains a number of economic disciplines.

Contracts are made in order to induce economic efficiency, i.e. to induce efficient decisions. Therefore it is natural to focus on how different decisions affect the economic outcome. *Neoclassic production economics* offers a solid basis for such analysis. Neoclassic production economics treats the firm and the market as black boxes, i.e. it ignores the role of internal conflicts in the firm and takes prices as given. The literature on contract theory has probably paid too little attention to the role of technology in contract design[1]. In this thesis the technology is included in the analysis of contracts under the headings coordination and efficiency, cf. part 5 of the thesis.

However, it is not satisfactory to consider the market as a black box. Often there is imperfect competition so that prices depend on the firm's behavior. Firms can act strategically and obtain market power. Similarly, the consequences of different actions depend on how other firms in the market react. *Industrial organization economics* focuses on the interaction between firms under imperfect competition.

[1] In the literature on agricultural economics, this critique has been raised by Chambers and Quiggin (2000).

The basic idea is that firms can affect the competitive environment through strategic behavior. *Non-cooperative game theory*[2] plays an important role in industrial organization economics. The theory analyses how different firms or individuals can identify and pursue common goals despite internal conflicts of interest.

The theories described so far treat the firms as black boxes, i.e. they do not deal with incentive problems within the firms. *Agency theory*[3] is concerned with the design of incentive schemes when one person (the agent) acts on behalf of another person (the principal). The provision of incentives is complicated by asymmetric information, i.e. information which only one of the parties in a contractual relationship has access to. The theory distinguishes between information asymmetry before the contract is made (adverse selection) and information asymmetry occurring after the contract is made (moral hazard). There is a huge amount of literature on optimal incentive schemes under different circumstances, e.g. different informational structures, repeated relationships, several agents, several dimensions of the agents actions.

Agency theory does not take into account that making a contract has a cost. *Transaction cost theory*[4] is concerned with the cost of entering into a contract. The literature defines transaction costs in two ways[5]. When transaction costs are defined broadly they include any kind of barrier to efficient decentralized exchange. The narrow definition of transaction costs, which is used in this thesis, includes only the cost of making, monitoring and enforcing contracts. Transaction costs lead to incomplete contracts which do not specify all possible contingencies. Incomplete contracts require renegotiation when unforeseen events occur.

Asset specificity plays an important role in transaction cost theory. A party who has invested in relationship-specific assets, which have a lower value outside the contractual relationship, is vulnerable when the contract is renegotiated. The other party can exploit this vulnerability to improve his trading terms. This is the hold-up problem. The theories of *property rights* and *corporate finance*[6] extends transaction cost theory and investigates how the problems associated with asset specificity should affect the ownership and financial structure of the firms.

Another type of transaction costs is *influence costs*[7], i.e. the costs arising from attempts to influence the decisions of others in a self-interested fashion. These cost are particularly relevant in cooperatives, where the members often have different goals.

The theories described above point to a number of different general economic problems common to all economic organizations. All economic systems, except simple Robinson Crusoe systems, involve several agents with conflicting interests,

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[2] See Tirole (1988) for a textbook on industrial organization economics and non-cooperative game theory.
[3] Cf. Bogetoft (1994) and Salanié (1997).
[4] See Williamson (1996).
[5] Cf. Deakin and Jonathan (1997).
[6] See Hart (1995).
[7] Cf. Milgrom and Roberts (1990).

private information and private possibilities to act. From the point of view of specialization, it can even be argued that the decentralization of information and decision-making among the agents is what gives a system the potential to operate more efficiently than a single individual. However specialization comes at a cost. Information must be shared and actions coordinated. There are three aspects of this. One is to define operating rules, i.e. coordination and decision-making rules for production. The other is to define incentive schemes to motivate the individuals to participate in the overall coordination and to choose optimal actions. The third problem is to minimize the coordination and motivation costs, i.e. to reduce the transaction costs of operating a decentralized and specialized system. Hence, the different economic problems of contract design fall into three main categories:

- *Coordination:* ensure that the right products are produced at the right time and place.
- *Motivation:* ensure that the contracting parties have individual incentives to take socially desirable decisions that maximize the total integrated profit.
- *Transaction costs:* ensure that coordination and motivation are provided at the lowest possible costs.

The characteristics of a given production and industry determines the relative importance of the different factors. For instance coordination may be the most important factor in one relationship while motivation may be the most important factor in another.

However, all elements should be included in the analysis of actual contracts, because the consequence of neglecting one aspect can be crucial. For instance, the full benefits of a perfectly coordinated production plan will only be achieved if the parties involved are motivated to follow the production plan. Thus, there is a real danger of sub-optimization where one aspect of a contract is improved at the expense of other and more important aspects. Therefore actual contracts should be analyzed *holistically.*

In this thesis the tools from the theory of *multi criteria decision making* are used to ensure the holistic analysis of contracts, i.e. the design of a contract is seen as a decision making problem. In particular goal hierarchies and a checklist are used in part 5 of this thesis.

From a theoretical point of view the holistic approach is not always the most fruitful. Often theoretical analyses require a more partial approach focusing on stylized models where it is possible to trace the effects analytically. This more theoretical approach is also used in this thesis, in particular in part 2-4.

2.2 The Industrial Background

It is obvious to apply contract theory to agricultural organizations for two reasons. Firstly, agriculture provides a number of good case studies, because the industry illustrates how different organizational forms work (e.g. spot markets, producer owned cooperatives, contract production, and vertical integration). Similarly, there is an open tradition in Danish agriculture. This means that there is relatively easy access to data on contracts (the actual contracts, production and price data, etc.). Secondly, there is increased use of contract production and other forms of vertical coordination in agriculture in Denmark and abroad. This process is often described as the industrialization of agriculture. Recent cases from two Danish feedstuff suppliers illustrate this development.

The investor-owned firm Hedegaard Foods has increased the vertical coordination of the egg production through new production contracts. The contracts ensure complete traceability, because Hedegaard Foods provides all inputs (chicks, feedstuffs, etc.). Hedegaard Foods is a subsidiary company of feedstuff supplier Hedegaard Ltd. Thus, in this example the feedstuff supplier use contracts to control the entire production chain.

In October 2001 the feedstuff supplier KFK Ltd. bought the firm DPL, Dansk Primær Landbrug Invest A/S (Danish Primary Agriculture Invest Ltd.). DLP is an investor owned firm with 21 production units producing 500.000 piglets and finishing 100.000 pigs. This is not the first example of vertical integration in Danish agriculture. There is a strong tradition for producer-owned cooperatives, i.e. vertical integrated firms owned by the farmers. However, the KFK case is the first example where investors own the entire production chain through vertically integrated firms.

The increase in vertical coordination through contracting and vertical integration is caused by a number of factors.

The *demand* for agricultural products is changing. A number of trends in the demand are connected with the production process and not the final product itself, e.g. animal welfare and organic products. Hence, traceability is an important quality parameter in modern food production.

Consumer definitions of quality have also become more diversified. Some consumers are highly focused on animal welfare (e.g. the UK market for pigs); other segments are more concerned with nutritional aspects or food safety. Many of these new requirements can only be met if the production is diversified at farm-level, and if the production process is well documented through credible monitoring systems.

Technological developments often increase the need of vertical coordination. New information systems and new methods for information processing make exchanges of information between different production levels more valuable. Computer technology has made it possible to collect and process large amounts of production data and thereby improve the production technology. Information may be more valuable if the transactions are based on contracts rather than on spot markets[8]. Contracting is one way to increase the exchange of information between different production levels. When KFK bought DPL one of the motivations was: "*KFK will*

[8] Cf. part 2 of this thesis and Hennessy (1996).

use DPL as a knowledge center, which beside the development of management know-how will contribute knowledge to the development of new feedstuff concepts", i.e. the strategy was motivated by information concerns.

Vertical integration regulate the inputs throughout the production chain, e.g. through contracts. This can increase efficiency, because the inputs are chosen according to considerations for the entire production chain, not just to satisfy the needs of one level of the production process.

Agricultural policy is changing in the industrialized countries. Price support is being phased out and often replaced by income support. This means that farmers face greater price risk. Contracts and other forms of vertical coordination can facilitate risk sharing. In particular contracts can shift risk away from small family farmers to larger investor-owned firms.

In parallel with the increase in vertical coordination there has been an *increase in the horizontal integration* between processors and retailers. Hence, in many markets the processors have obtained local monopsony power through a series of mergers. A monopsonistic processor operating in a spot market will reduce his demand and thereby exploit his market power. In such a situation contracts can be used to introduce two-part tariff systems and thereby remove the problem of double marginalization.

A processor can use contracts to prevent competitors from entering the market (deterred entry) and thereby increase his market power. In markets where contract production or vertical integration is predominant, the traditional spot market may disappear.

Disappearing spot markets mean that there are no market prices to rely on for determining internal transfer prices in the production chain. Hence, the parties must base their incentive schemes on other measures.

3 The Papers

The remainder of this Ph.D. thesis consists of four independent parts. The work falls into two categories:

1. *Theoretical papers based on stylized models* (part 2-4).
   The first paper shows how the value of noisy information depends on the competitive regime. The second paper shows how a principal can create implicit discrimination through strategic group division and relative performance evaluation. The third paper shows how auction design affects the efficiency of milk quota re-allocation.
2. *Contract theory applied to specific contractual relationships* (part 5).
   The book "Design of Production Contracts: Lessons from Theory and Danish Agriculture" concludes the project "Economic Analysis of Contracts in the Danish Agriculture". The book contains a summary of the findings in the project, an

overview of the contract theory, in depth analysis of two specific contracts, fact sheets outlining the most important aspects of eight different production contracts.

The four parts are:

2. Bogetoft and Olesen, "Incentives, Information Systems and Competition", pp. 24-52, forthcoming in *American Journal of Agricultural Economics*[9]

3. Olesen and Olsen, "Discrimination and Group Division in Tournaments", pp.53-76[10].

4. Bogetoft, Jensen, Nielsen, Olesen and Olsen, "Single Bid Restriction in Milk Quota Exchanges – A Comparison of the Danish and the Ontario Exchanges", pp. 77-99.

5. Bogetoft and Olesen, "Design of Production Contracts: Lessons from Theory and Danish Agriculture", pp. 100-266.

This book contains the following chapters:

1. Introduction, pp. 104-110.
2. Ten Rules of Thumb in Contract Design: Lessons from Danish Agriculture, pp. 111-136.
3. Contract Theory: A Holistic Approach, pp. 137-158.
4. Contract Production of Peas, pp. 159-181.[11]
5. Contract Production of Special Pigs: Fixed or Market-determined Bonuses, pp. 182-204.
6. The Practice of Contracting: Fact sheets, pp. 205-259.
   - 5.1. Introduction
   - 5.2. Peas
   - 5.3. Special Pigs
   - 5.4. Broilers
   - 5.5. Eggs
   - 5.6. Fruit
   - 5.7. Grass and Clover Seed
   - 5.8. Sugar Beets
   - 5.9. Potatoes

In the following I give a summary of each of these papers.

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[9] An earlier version of the paper was published as CIE-Discussion Paper, Copenhagen University, 2000-12.

[10] A previous version of the paper was published as Unit of Economics Working Paper, The Royal Veterinary and Agricultural University, Copenhagen, 2001/4.

[11] An earlier version of the chapter was published as Unit of Economics Working Paper, The Royal Veterinary and Agricultural University, Copenhagen, 2001/4.

4 Incentives, Information Systems and Competition

By Peter Bogetoft and Henrik Ballebye Olesen.

We investigate how different competitive regimes affect the ability to provide incentives based on noisy information systems. The set-up involves multiple producers and processors in a world with moral hazard and adverse selection. We illustrate how competition may cripple the use of a noisy information system for incentive purposes.

We assume that the parties are risk neutral, so first-best implementation is possible if the information system is just slightly informative. However, this requires that the processors compete before the revelation of signals, *a priori competition*. In such cases, more high-powered incentives can simply be used to compensate for the lack of reliable information. This contradicts previous claims in the agricultural economics literature on grading.

With competition after grading, *a posteriori competition*, the need to pay expected values for each grade makes it impossible to motivate first-best investment choices. The reason is that payment of expected values does not allow for sufficiently high-powered incentive schemes.

A *monopsonist* trading after the investment cannot induce any investment because the producers face a hold-up problem. A monopsonist using long-term contracts can avoid the hold-up problem. To save on information rents, he will however ration the producers that are induced to invest.

Enforcement of long-term contracts is easier under monopsony than under competition. One reason for this is that a producer acquiring additional information before grading would be tempted to sell his products outside the contract, and that such breaches of contract may be hard to observe and penalize. It is therefore suggested that the comparison between *a priori monopsony* and *a posteriori competition* is the most relevant.

Our main finding is now that *a monopsonist regime may be superior to a competitive one. The loss from rationing introduced by a monopsonist may be more than offset by the increase in investment caused by its ability to use a more high powered payment plan. Hence, it may be socially advantageous to induce the processors to collude. A monopsonist may also be favorable for producers since their profits may be higher in a monopsonist regime than under a competitive one.*

Although this is a simple set of observations, they may rationalize horizontal and vertical integration simply because such integrations reduce competition and thereby allow for stronger incentives. They may also explain why it is common in agricultural markets that grading takes place at the processors with trading terms settled before the actual grading.

5 Discrimination and Group Division in Tournaments

By Henrik Ballebye Olesen and René Housøe Olsen.

The contracts we consider in this paper must solve three problems: moral hazard, insurance and discrimination. The moral hazard problem is that of providing the agents with incentives to perform in a way that maximizes the profit to the principal, when the agent's actions are unobservable. The insurance problem is that of reducing the cost of risk through risk minimization and risk sharing. The issue of discrimination is that of paying agents who have superior skills sufficient to participate, without over-compensating other agents.

The discrimination effect causes distortion in the level of effort. Consider case A, when the low-skilled agents receive quasirents. In this case, it is optimal for the principal to use stronger incentives and stimulate a higher level of effort. Stronger incentives reduce the quasi-rents to low-skilled agents via a stronger punishment. In case B, the high-skilled agents receive quasi-rents. Here it is optimal for the principal to use weaker incentives. This distorts the level of effort downwards and reduces the quasirents to the high-skilled agents, since these agents benefit less from having better skills. In case C, where none of the agents receives quasi-rents, the discrimination effect may lead to either weaker or stronger incentives.

The principal can divide the agents into groups strategically. If the principal distorts the level of effort upward in case C, he may gain in two ways from dividing the agents into more heterogeneous groups. Firstly, the distortion in the level of effort falls, since the level of effort is lower in smaller groups. Secondly, the risk premium decreases due to weaker incentives.

The analysis emphasizes a controversial aspect of tournaments. A principal can use tournaments to discriminate between heterogeneous agents, especially if he uses his authority to divide the agents into groups. The discrimination in tournaments can increase the principal's profit, but this is often at the expense of the agents. This may explain why producers in many cases oppose the use of tournaments in agricultural contracts.

6 Single Bid Restriction in Milk Quota Exchanges: A Comparison of the Danish and the Ontario Exchanges

By Peter Bogetoft, Peter Max Friis Jensen, Kurt Nielsen, Henrik Ballebye Olesen and René Olsen.

This paper investigates the auction rules of the Danish milk quota exchange, with the focus on the restriction that each producer may only submit a single bid, the single-bid restriction. We develop an analytical model of the problem based on the theory of double auctions.

The single-bid restriction creates distortions for two reasons:

1. The aggregation effect: The single bid restriction limits the information transmitted through the exchange, e.g. the buyer cannot express a downward sloping demand curve.
2. The uncertainty effect: The uncertainty about the clearing price systematically affects the producers' bids/asks, so that they submit the average value rather than the marginal value of quota.

It is shown that a multiple bid exchange will eliminate these inefficiencies. In other words, introducing multiple bids will generate efficient trade.

We use data from the (multiple bids) Ontario milk quota exchange to evaluate the empirical impact of the single bid restriction.

7 Design of Production Contracts: Lessons from Theory and Danish Agriculture

By Peter Bogetoft and Henrik Ballebye Olesen

This book is based on the study of a number of contracts between processors and Danish farmers. The aim of the study has been to develop a theoretical framework for the analysis of agricultural contracts and to use this framework to understand actual contractual relationships. The book contains the five parts described below.

7.1 Ten Rules of Thumb in Contract Design: Lessons from Danish Agricultural Contracts

This paper[12] combines contract theory and experiences from actual contracts. After studying eight different contracts between producers and processors in Danish agriculture, we have developed a checklist for contract design. The checklist contains ten rules of thumb in contract design. The rules on the checklist cover the most important problems in agricultural contracts between producers and processors.

The motivation for the paper is that real contracts must balance a number of conflicting objectives by taking into account a number of different aspects of the contracting situation. Contract theory provides useful insights, but the formal models used in the theory tend to focus on a few effects in stylized environments. The risk of a too partial approach is that while improving one aspect of a contract, new and more serious problems may arise in other aspects. Practical contract design can therefore benefit from a more systematic approach ensuring that all relevant aspects are considered.

The ten rules of thumb for contract design are:

1. *Coordinate production:* It is an important for contracts to coordinate the actions of independent decision-makers. This coordination can be achieved either through instructions or through price signals.
2. *Reduce the costs of post-contractual opportunism:* Often the processor cannot observe the actions taken by the producers after the contract has been signed. The contract should motivate the parties to take the right actions.
3. *Reduce the costs of pre-contractual opportunism:* Often the producers (or the processors) have private information about their skills, cost structure etc. before the contract is signed. This may lead to adverse selection problems and may enable producers to obtain information rents.
4. *Reduce the direct costs of contracting:* The direct costs of contracting are the time and money spent on information collection, monitoring, bargaining, conflict resolution etc.
5. *Minimize the costs of risk and uncertainty:* The cost of risk and uncertainty can be reduced through risk minimization and risk sharing.
6. *Do not kill cooperation:* The contract should induce cooperation and sharing of information about production techniques, etc. However, cooperation can give rise to influence costs from activities designed to influence the decisions of others in a self-interested fashion.
7. *Motivate long-term concerns:* The contract should induce the parties to take the long-term effects of their actions into consideration.

[12] The paper has been submitted to the European Journal of Agricultural Economics, the paper is waiting for second round of revision.

8. *Balance the costs and benefits of renegotiation:* Renegotiation facilitates flexible contracts, but reduces the commitment and may lead to strategic behavior.
9. *Balance the costs and benefits of decentralization:* allocate decision-making rights so that decisions are coordinated, costly communication is minimized and important information is utilized.
10. *Use transparent contracts:* The contracts must take account of the parties' bounded rationality. It is important to use simple contracts, so that the parties easily can relate the incentives to their decisions.

7.2 Contract Theory: A Holistic Approach

This chapter provides an outline of the contract theory. The chapter focuses on the aspects of contract theory that are most relevant for contract between producers and processors in the agriculture.

The basic idea in the chapter is to develop a holistic framework for the analysis of contracts. The different aspects of contract theory are arranged in a goal hierarchy, which can be used by practitioners as a guideline for contract design. Researchers can also use the goal hierarchy as a tool in contract analysis.

The goal hierarchy is developed around the three main aspects of contract theory: coordination, motivation and transaction costs (cf. section 2.1). The goal hierarchy addresses both short and long-run problems in contractual relationships.

7.3 Contract Production of Peas

This paper analyzes a contract between farmers and a large company in the Danish food industry, Danisco Foods. Production of green peas for consumption requires a highly accurate coordination, which is obtained through centralized decision-making. The contract is based on a tournament system providing risk sharing between the farmers. General problems from contract theory such as hold-up, moral hazard, risk sharing and discrimination are analyzed. The paper illustrates the tradeoffs between these problems in the design of contracts. By negotiating the contract through a pea-growers association, the farmers gain some bargaining power. Thus the farmers can ensure that Danisco Foods only uses one contract for all farmers. This paper analyzes the consequences of the farmers' strategy. Throughout the analysis several modifications of the contract are suggested in order to improve the incentives.

7.4 Contract Production of Special Pigs: Fixed vs. Market-determined Bonuses

This paper compares two bonus systems used by the cooperative, Danish Crown, to pay producers of special pigs. The market-determined bonus system let the bonus for producing special pigs (as opposed to ordinary pigs) increase in proportion to the quantity of the special pigs actually sold as special pigs (rather than as ordinary pigs). In the fixed bonus system, the bonus does not depend on the extent to which the pigs are actually sold as special pigs. The ordinary producers have the majority in the cooperative. That means that the ordinary producers can control the cooperative in a way that maximizes their profit – and not the integrated profit.

It is shown that the two bonus systems lead to different conflicts between special producers and ordinary producers. The market-determined bonus system creates conflicts concerning the processing and sale of special pigs. In this system, the ordinary producers have incentives to reduce the sales of special pigs to save on the bonus payment. The fixed bonus system creates conflicts concerning the production level. In this system, the ordinary producers have incentives to reduce the production of special pigs.

In January 2000 Danish Crown changed the bonus system for some special pigs from the fixed bonus to the market-determined bonus. We show that this change was beneficial for the ordinary producers, while the special producers were worse off after the change. We use empirical data to quantify the effects of using one or the other system.

7.5 Contracting in Practice: Fact Sheets

We have studied contracts representing a broad spectrum of agricultural productions in Denmark. The production and market conditions, the ownership structure (who owns the processor) and the most important elements of these contracts are described in fact sheets. The fact sheets are based on the contracts (the legal documents), interviews with representatives from the industry and other background material.

The contracts we have studied covers the following sectors:

- **Special Pigs:** contracts between Denmark's largest slaughterhouse, Danish Crown, and producers of special pigs (e.g. UK pigs, free range pigs and organic pigs). Danish Crown is a cooperative and the contracts reflect some of the difficulties in contracting with different producer groups within a cooperative.
- **Broilers:** contract between private producers and the investor-owned Rose Poultry. The contracts ensure a high level of food safety through the tight control of inputs.
- **Eggs:** contracts between the cooperative Danæg and producers of battery eggs, deep litter eggs, free-range eggs and organic eggs, respectively. The

contracts coordinate the combating of disease at the different levels of the production.
- **Peas:** contracts between producers of peas and the investor-owned Danisco Foods. The contracts provide very precise coordination and provide risk-sharing through tournaments.
- **Grass and Clover Seed:** contracts between producers and the three major processors in the industry: DLF Trifolium (a producer-owned cooperative with a market share of 74 percent of the Danish production), Hunsballe Frø, (owned by a private foundation), and the investor-owned Wibollt, both with a market share of 12 percent. The contracts are very similar. However, some of the contract details reflect the differences in ownership structures.
- **Fruit:** contracts between producers of blackcurrants and cherries and the investor-owned processor Vallø Saft. The contracts facilitate both coordination and use of local information in the harvesting process.
- **Potatoes:** contracts between producers of potatoes and their cooperative AKV Langholt. The potatoes are processed into starch. The total quantity is regulated through tradable production rights.
- **Sugar Beet:** contracts between producers and the investor-owned Danisco Sugar. The production of sugar is highly regulated in the EC. The producers have non-tradable production quotas.

8 Related work

During my Ph.D. study I have been working on two issues related to the work included in this thesis (1) the economics of cooperatives and (2) extension papers.

8.1 The Economics of Cooperatives

The economics of cooperatives are closely related to contract theory, but the focus is different. Contract theory focuses on the vertical relationship between the processors and the producers of a particular product (e.g. organic pigs). The economics of cooperatives has a broader perspective and focuses on the entire cooperative (the firm and the members), i.e. both the vertical relationships between the producers and the processors and the horizontal relationships between the producers in the cooperative. The interaction between producer groups (e.g. organic and conventional producers) plays an important role in the economics of cooperatives.

My work in this field is contained in the book:

- Bogetoft and Olesen, ”Payment Schemes in Cooperatives: theoretical models and examples from the Danish pig industry", 260 pp, 2001c[13].

The book establishes an analytical framework which decision-makers in co-operatives can use for evaluating how well the alternative payment schemes satisfy the aims of the members.

Recent developments in the Danish pig industry, including increased product differentiation, are taken as the starting point. These developments mean that within cooperative slaughterhouses there are many different producer groups with partially conflicting interests.

The overall goal of a co-operative is to secure the highest possible economic welfare for its members. We have divided this goal into a number of subordinate goals. Using these subordinate goals we have established a number of operational criteria which a payment scheme should satisfy.

One subordinate goal is that the payment scheme should co-ordinate the activities of the members so that the right goods are produced at the right time and place. The system ought also to reduce risks for individual members and have a minimum information requirement.

A second subordinate goal is that a payment scheme should provide the necessary motivation for members to have a personal interest in carrying out the activities which best benefit the cooperative. This means, among other things, that all producer groups must gain from participation in the cooperative. This also requires that the payment scheme should lead to flexible decision-making processes so the members do not spend too much effort on internal conflicts.

A third subordinate goal for a payment scheme is that it should be able to operate in a dynamic perspective. The payment scheme should induce appropriate investments, both by the primary producers and by the cooperative. The payment scheme should also be sufficiently robust so there is a reasonable adjustment of payment when production or market conditions change.

We argue that it is impossible to satisfy all these requirements simultaneously. Therefore it is necessary to make trade-offs between the individual criteria when designing a payment scheme. We suggest that these trade-offs should be made with the help of a systematic multiple-criteria approach.

We analyze a number of payment schemes which each satisfy certain criteria. We consider a number of payment schemes for a cooperative with just one product type. We show that the traditional payment scheme of cooperatives, with payment in proportion to the quantities delivered, is optimal under certain circumstances. However, in a number of situations it induces over-production. We show how this problem can be solved by adjustments to the payment scheme.

[13] The book was published in Danish in 2000 as: Bogetoft and Olesen ”Afregning i Andelsselskaber: teoretiske modeller og praktiske eksempler fra slagteribranchen”, DSR Forlag. The Danish book has been used as textbook in the course ”The Economics of Co-operatives”, which I taught during the fall of 2001.

We also analyze a number of both practical and theoretical payment schemes for cooperatives with more than one product type. None of the payment schemes is absolutely best, so when choosing a payment scheme it is necessary to decide which of the criteria is most important in the given situation. Our analyses point to two payment schemes that are particularly relevant. One is the national pricing scheme where the gross margins are the same for all types of production. The other payment scheme, which we call the premium pig scheme, is based on the principle that each pig shall be paid for on the basis of its marginal revenue. This will lead to a surplus in the cooperative, which is allocated according premium rights that can be traded internally between members.

8.2 Extension Papers

The work in my Ph.D. thesis and my work on the economics of cooperatives has resulted in two extension papers published in Danish farming periodicals.

- Olesen and Wiborg, "What does a good contract contain?" (in Danish), *Produktionsøkonomi, Svinehold* , Landbrugets Rådgivningscenter, Århus, 8 pp., 2001.
  The paper uses the framework form chapter 2 in part 5 of this thesis to define a number of criteria for a good contract between producers of piglets and producers of slaughter pigs. The paper was distributed to Danish pig producers and consultants in the agricultural advisory service.
- Bogetoft and Olesen "Evaluation of Payment Schemes" (in Danish), Tidsskrift for Landøkonomi, October 2000, 15 pp.
  The paper summarizes the Danish book on payment schemes in cooperatives of Bogetoft and Olesen (2000).

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Part 2.

Incentives, Information Systems and Competition

Part 2.

Incentives, Information Systems and Competition

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Abstract

We investigate how di¤erent competitive regimes a¤ect the ability to provide incentives based on noisy information systems. The set-up involves multiple producers and processors in a world with moral hazard and adverse selection. Reduced competition may facilitate incentive provision by allowing more high powered incentives. This may rationalize both vertical and horizontal integration as seen in many agricultural markets with uncertain quality grading. On the other hand, if trading terms are settled before the information is observed, a noisy information system may su¢ce to give proper incentives. This may rationalize the use of long term conditional price contracts in the trading of many agricultural products.

1 Introduction

In this paper, we investigate how competition among processors a¤ect their possibility to motivate appropriate investments at producers. The set-up involves moral hazard as the investment levels cannot be precisely monitored.

It also involves adverse selection as the investment costs are private information to the producers. Alternative competitive regimes are de…ned by the number of processors and the length of the contracts signed (or equivalently, the timing of the investment and pricing decisions).

We will show how the relative merits of alternative competitive regimes depend on a trade-o¤ between three basic issues, viz. incentive power, rationing and hold-up. The advantage of having multiple processors is to eliminate the hold-up problem that occurs under monopsony when prices are settled after investment (short contracts). Competition among processors also eliminates the rationing of investment that occurs under monopsony when prices are settles before investment (long contracts). The disadvantage of having multiple processors however is that the competition to attract producers may limit the ability to provide high powered incentives when prices are settled after investment (short contracts). This limitation is created as we shall show by the necessity under competition to pay the expected value given the information from a noisy information system. We shall demonstrate also how this competitive disadvantage can be eliminated if prices are settled before investment (long contracts).

These results have numerous application in agricultural economics. In many markets, the producers have superior information about their cost of quality improvements, i.e. an adverse selection problem exists. Moreover, the processors cannot observe quality improving actions with certainty but must rely on "noisy" grading systems. The uncertainty is due to simple grading errors and - more importantly - the stochastic impact of investment on the resulting characteristics of the products. Either way, the resulting relationship between a producer's behavior and his grading results is uncertain and a moral hazard problem exists.

Horizontal integration of the processors transforms the set-up from a competitive to a monopsonistic one. In a monopsonistic set-up the processors can deviate from expected value payment and therefore use more high powered incentive schemes. This may for example rationalize agricultural procurement boards.

Horizontal integration of producers transforms the set-up to one of a monopoly. A monopolist can o¤er prices deviating from expected value payment and hereby reduce the incentive problem. This may explain the use of marketing boards and bargaining associations in agricultural production where grading may not be entirely precise, - cf. e.g. Chalfant et al.

Vertical integration ties the processor and one or more producers together for at least a period of time. In the full integration case, the processor and producers merge. It is often held that vertical integration mitigates incentive con‡icts by internalizing the incentive con‡icts, cf. e.g. Williamson. Usually, it is believed that there are better information systems and other means of rewarding and punishing the agents inside a …rm than between …rms. We suggest that reduced competition may be a speci…c way in which vertical integration can improve the use of information systems and the possibilities of reward and punishment. In turn, this may rationalize the widespread industrialization of agricultural production through the use of production and marketing contracts.

There is a large literature on moral hazard and adverse selection but only a more limited literature on how such issues interact with competition. An early contribution is Akerlof's classical article about lemons in a used car market. The inability of buyers to observe the quality of used cars can make a competitive market break down by the sellers only o¤ering below average quality cars which the buyers foresee. Since Akerlof, there has been several suggestions on how to improve the incentives in a market with imperfect testing. Leland analyzes how licensing (or minimum quality constraints) can improve product quality. Heinkel shows how the use of penalties in a rank order tournament based on an imperfect test can reduce the lemons problem. However, the approach suggested by Heinkel does not in general implement …rst-best, because the penalty implies a direct welfare loss (burning money). Mason and Sterbenz analyze the incentives for producers to undertake costly certi…cation. The producers are able to conceal information about unfavorable test results. This approach can lead to improved as well as a reduced incentives compared to the case of no testing. Hollander, Monier and Ossard take the …rms' quality levels as given and explore the incentives to participate in voluntary grading for high and low quality …rms, respectively.

The paper most directly related to the present is probably Hennessy who suggests that vertical integration may be a way to overcome the di¢culties of grading agricultural products. We complement the work of Hennessy by demonstrating that vertical integration is only one of a series of remedies. Other remedies are "a priori competition", horizontal integration of producers, and horizontal integration of processors as we shall discuss below.

A related paper focussing on noisy grading systems is Chalfant et al. They develop a theoretical model showing that grading errors will lead to wrong incentives. We shall emphasize that these results hold in a competitive regime where trade occurs after grading - but not necessarily in other competitive regimes. Moreover, we will show that the problem of providing proper incentives based on noisy grading does not exist in a competitive regime if there is no trade after grading. Also we will argue that this is likely to be the case in the examples considered by Hennessy and Chalfant et al.

We also deviate from Hennessy and Chalfant et al. by developing an explicit model of the resulting ine¢ciencies (in terms of an under-supply of e¤ort or investment). Lastly, our set-up allows us to relate the e¢ciency loss from competition to the characteristics in the grading system.

The paper is organized as follows. In Section 2, we introduce the model and we identify the …rst-best outcome. In Section 3, we develop the a posteriori competitive outcome, i.e. the outcome when trade takes place after observing the information system. In Section 4, we develop the outcome in case of a priori competition, i.e. when conditional trading terms are settled before the actual information is observed. We also discuss the possibilities of accomplishing this via vertical integration of producers and processors or via horizontal integration of producers. In Section 5, we formalize the monopsony outcomes corresponding to a horizontal integration of processors. Numerical examples are provided in Section 6 and …nal remarks are given in Section 7. In a supplementary appendix, we generalize our results.

2 Basic Model and First Best

Consider a set-up with multiple, risk neutral and pro…t maximizing producers and processors[1]. Each producer produces and delivers one good to one of the processors. For simplicity, we assume that each processor can process in…nitely many goods and that the processors' reservation pro…ts are zero. The producers' production costs and reservation pro…ts are normalized to zero as well.

Each producer has the possibility of making an investment that a¤ects the value to the processors of his product. The expected value of the good to a processor depends on the producer's investment as follows

	Expected value
Investment	$V_0 + V$
No Investment	V_0

[1] Introducing risk averse producers will complicate the model signi…cantly without changing the nature of our results.

i.e. the investment increases the expected value of the good from $V_0 \geq 0$ to $V_0 + V$, where $V \geq 0$.

The processors cannot directly monitor the producers' behavior. However, the processors do get a signal about the quality of the products. The grade of a given producer's product can be either H (high) or L (low). The probability of receiving these grades given the investment behavior is

	H	L
Investment	$\alpha + \delta$	$1 - \alpha - \delta$
No Investment	α	$1 - \alpha$

where $\alpha, \delta \geq 0$ and $\alpha + \delta \leq 1$. Hence a more informative information system is associated with larger values of δ. Even though we only focus on two grades, all our results can easily be generalized to n grades (see the appendix).

A producer's actual cost of investing c is known only by him. The cumulative distribution $F(c)$ of c is common knowledge[2] and satisfies $F(c) > 0$ and $F'(c) > 0$ for all $c > 0$. The investment in quality improvement could be the thinning of prune trees (as Chalfant et al.), the investment in a new refrigerated bulk storage tank (as Hennessy), soil improvements, etc.

Since a producer's investment cannot be observed by the processor, the price offered to the producer can only be conditioned on the signal from the information system. Let P_H be the producer's payment if the signal is H and P_L the payment when the signal is L.

The producer will choose to invest if and only if

$$(\alpha + \delta) P_H + (1 - \alpha - \delta) P_L - c \geq \alpha P_H + (1 - \alpha) P_L$$

i.e. investing is incentive compatible if and only if

$$c \leq \delta (P_H - P_L) \tag{1}$$

This shows that with grade dependent prices, a producer's behavior is characterized by a cost threshold $\delta(P_H - P_L)$ below which he invests and above which he does not. This also means, that alternative payment schemes can

[2] In fact, our modelling only requires that the processors use the same $F(c)$, and that producers know this $F(c)$. I.e. our results do not change if the producers' beliefs about $F(c)$ differ from the processors' beliefs. Neither do our results change if the distribution of c is discrete.

be compared through the cost thresholds that they generate. These properties are shared by many models with private investment costs, cf. e.g. Antle, Bogetoft and Stark (1999, 2000).

In terms of participation, we have that a non-investing producer is willing to produce under the $(P_H; P_L)$ contract as long as

$$P_H \alpha + P_L (1 - \alpha) \geq 0 \tag{2}$$

Similarly an investing producer will participate if

$$P_H (\alpha + \delta) + P_L (1 - \alpha - \delta) - c \geq 0 \tag{3}$$

The last constraint is most demanding for high c values. Inserting the highest c value leading to investment, i.e. $c = \delta (P_H - P_L)$; into (3), we see that (3) reduces to (2)[3]. Hence, in terms of participation, we simply must require (2).

The first-best investment plan is to invest as long as marginal value exceeds marginal cost, i.e.

$$c \leq V \tag{4}$$

Let c^{FB} be the first best cost threshold, i.e. $c^{FB} = V$. It follows from (1) that to implement the first best level of investment using $(P_H; P_L)$; we must have

$$P_H - P_L = \frac{V}{\delta}$$

Note that a less informative system with a small δ requires a more high powered or progressive incentive scheme with a large price gap $(P_H - P_L)$ to implement first best investment.

3 A posteriori competition

Assume now that trade takes place after grading. We call this a posteriori competition. The setting is illustrated in Figure 1.

We will now show that the processors cannot use high-powered incentives under a posteriori competition.

[3] This is not surprising since the most costly type that invests, i.e. $c = \delta(P_H - P_L)$, is indifferent between investing and not investing.

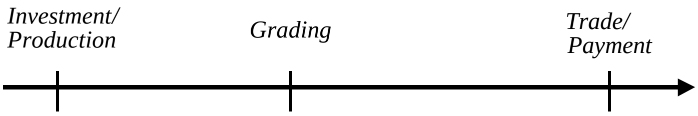

Figure 1: A Posteriori Competition

By a Bertrand-like argument it follows that the processors must pay the expected value of a good given its grade. The reason is that if a processor pays a producer less than the expected value of his good given his grading, a second processor could offer to pay more and still earn a positive profit. On the other hand, a producer can get no more than the expected value of his good since a processor paying more would be better off foregoing the trade.

To further examine the a posteriori competitive regime, we calculate the probability that a producer has invested given the grading result. Let c be the highest cost type that chooses to invest. Hereby, $F(c)$ is the a priori probability that the producer invests. Using Bayes' Rule, the a posteriori probability that he invested when the processors receive the signal H is

$$p(inv|H) = \frac{F(c)(\alpha + \delta)}{\alpha + \delta F(c)}$$

and the probability that the producer invested when the signal is L, is

$$p(inv|L) = \frac{F(c)(1 - \alpha - \delta)}{1 - \alpha - \delta F(c)}$$

As argued above, competition forces the processors to pay the expected value of the good given its grade. This means that the prices P_H and P_L are

$$\begin{aligned} P_H &= \text{Expected value of grade } H \\ &= p(inv|H)(V_0 + V) + p(\text{no } inv|H)V_0 \\ &= V_0 + p(inv|H)V \\ &= V_0 + \frac{F(c)(\alpha + \delta)}{\alpha + \delta F(c)}V \end{aligned} \tag{5}$$

$$
\begin{aligned}
P_L &= \text{Expected value of grade } L && (6)\\
&= p(inv|L)\,(V_0 + V) + p\,(\text{no } inv|L)\,V_0\\
&= V_0 + p(inv|L)V\\
&= V_0 + \frac{F(c)\,(1-\alpha-\delta)}{1-\alpha-\delta F(c)}V
\end{aligned}
$$

Given this price scheme and (1), the producers will choose to invest for all costs below c^{CO} where

$$c^{CO} = \delta(P_H - P_L)$$

i.e. c^{CO} solves

$$c^{CO} = \left[\frac{F\left(c^{CO}\right)(\alpha+\delta)}{\alpha+\delta F(c^{CO})} - \frac{F\left(c^{CO}\right)(1-\alpha-\delta)}{1-\alpha-\delta F(c^{CO})}\right]\delta V \tag{7}$$

Also, using this investment strategy, the participation constraints are fulfilled. To see this, use $c^{CO} = \delta\,(P_H - P_L)$ to rewrite the participation constraint (2) to $\frac{\alpha}{\delta}c^{CO} + P_L \geq 0$. Inserting P_L from (6), we see that (2) is equivalent to

$$\frac{\alpha}{\delta}c^{CO} + V_0 + \frac{F(c)\,(1-\alpha-\delta)}{1-\alpha-\delta F(c)}V \geq 0$$

which is always fulfilled.

We see now that a posteriori competition leads to under-investment, i.e.[4]

$$c^{CO} \leq c^{FB} = V$$

Hence, there is a social loss from settling prices based on signals from a noisy grading system. Competition forces the processors to pay expected values and this leads to payment schemes that are not sufficiently high powered to encourage first best investment.

The obvious agricultural example of the a posteriori competitive regime is trading of products at an auction. When vegetables, flowers, fur etc. are

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[4] By $(1-\alpha-\delta) \geq 0$, we have $\frac{F(c^{CO})(1-\alpha-\delta)}{1-\alpha-\delta F(c^{CO})} \geq 0$; and therefore $c^{CO} = \left[\frac{F(c^{CO})(\alpha+\delta)}{\alpha+\delta F(c^{CO})} - \frac{F(c^{CO})(1-\alpha-\delta)}{1-\alpha-\delta F(c^{CO})}\right]\delta V \leq \frac{F(c^{CO})(\alpha+\delta)}{\alpha+\delta F(c^{CO})}\delta V < V$.

brought to an auction, the processors can get a (noisy) signal of quality from direct inspection of the products. The bidding process therefore makes the processors pay the a posteriori expected values. Another example of this regime could be the trading of grain, where the farmers can get a sample graded before trading.

Despite such examples, the a posteriori competitive regime is probably not the most common in modern agriculture. Goods are often graded at the processor after delivery from a producer and grade dependent prices are usually settled before delivery.

Hennessy and Chalfant et al. both implicitly base their models on the a posteriori competitive regime. Hennessy uses the case of a dairy farmer investing in a new refrigerated bulk storage tank in order to reduce milk bacterial counts. This case does not seem to …t the regime of trade after grading, since milk typically is graded after delivery - there is no market for already graded milk. The a priori competitive regime developed in the Section 4 may therefore be more appropriate. Chalfant et al. use the case of California prunes which are graded by the processor, and where the prices are negotiated in advance and …xed for the season. Hence, the market for prunes may not correspond to the regime of a posteriori trade because there is no competition after grading. Again, the regime developed in the next section seems more appropriate.

4 A priori competition

When prices for the di¤erent grades are …xed in a competitive market before the investment, we talk about the regime as one with a priori competition. This setting is depicted in Figure 2.

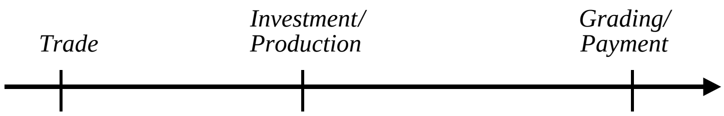

Figure 2: A Priori Competition

When trade takes place before grading, competition does not force the processors to pay the expected value of the good given its grade[5]. Rather, competition forces the processors to pay the expected value of the good before grading. Again this is based on a Bertrand-like argument. For producers who have invested, this means that they should expect a payment of $V_0 + V$ while producers without investment should expect a payment of V_0. We shall now demonstrate this. Also, we shall demonstrate that the resulting investment levels are first best because the processors use high-powered incentives.

The structure of the problem, including the risk neutrality, implies that there are multiple equilibria. Several contracts can exist simultaneously in the market, some attracting both investing and non-investing producers (pooling contracts) and other attracting only investing or non-investing producers (separating contracts). They all have the property, however, that the producers are paid the expected value of their products. This is consequence of competition forcing the processors to break-even producer by producer.

To see this in more details and develop the basic properties of the outcome, let us assume that $(P_L; P_H)$ is (a non-trivial) part of an equilibrium. By this we mean that at least one processor offers this contract to one or more of the producers and that at least one producer actually chooses this contract. Now, let us assume that the fraction β of the producers operating under $(P_L; P_H)$ chooses to invest and that the rest $(1 - \beta)$ chooses not to invest. Then we must have

$$\begin{aligned}&\beta[P_H(\alpha + \delta) + P_L(1 - \alpha - \delta)] + (1 - \beta)[P_H(\alpha) + P_L(1 - \alpha)] \\ &= \beta[V_0 + V] + (1 - \beta)[V_0]\end{aligned}$$

since the left hand side is the expected payment to the producers and the right hand side is the expected value they generate[6].

[5] We note that our definition of a priori competition - as illustrated in Figure 2 - is stronger than what we need in this section. For the argument of this section, it suffices that trade takes place before grading. We nevertheless assume that trade takes place before investment as well. We do so to ease the comparison with the monopsonist case. Still, the possibility of investment before trading is a strong reminder of the usefulness of competition to eliminate hold-up problems.

[6] Formally, the proof of = runs as follows: We cannot have > since then the processor suffers a strict loss and he would be better off not offering the contract. We cannot have < since then one of the processors could increase all prices marginally to $(P_L + \varepsilon; P_H + \varepsilon)$. Hereby he would attract all the types that traded under the old contract and he would only have to pay ε more. I.e. a marginal increase in price would induce a non-marginal increase in trade.

We will now show that the expected payment not only equals expected value when averaged over investing and not-investing producers, it holds for the individual producers as well.

Consider first the case of a pooling contract, i.e. $0 < \beta < 1$. In this case we must have

$$P_H(\alpha + \delta) + P_L(1 - \alpha - \delta) = V + V_0 \tag{8}$$

$$P_H(\alpha) + P_L(1 - \alpha) = V_0 \tag{9}$$

To see this, assume that we have $>$ in (8) and $<$ in (9). In this case, the processors lose on the investing producers but gain on the non-investing ones. A processor could now modify the contract to $(P_H - \Delta/\alpha; P_L + \Delta/(1 - \alpha))$. This would not affect the non-investing types, but the investing types would be paid less. The processor will therefore be able to attract the same number of non-investing producers but he would lose less on the investing producers (he may not even attract any). Similarly, we cannot have $<$ in (8) and $>$ in (9). In this case, a processor could modify his contract to become $(P_H + \Delta/(\alpha + \delta); P_L - \Delta/(1 - \alpha - \delta))$: This would not affect the expected payment to the investing types but it would reduce the payment to the now overpaid and loss generating non-investing producers. In summary, a pooling contract must satisfy both (8) and (9). The price scheme satisfying these restrictions is

$$P_H = V_0 - \frac{\alpha V}{\delta} + \frac{V}{\delta} \tag{10}$$

$$P_L = V_0 - \frac{\alpha V}{\delta} \tag{11}$$

We emphasize that these prices satisfy the participation constraints even if P_L is negative[7].

In addition to the pooling contracts there exist separating contracts that only attract the producers who have invested or those who have not invested. Consider first contracts that only attract investing producers. This corresponds to $\beta = 1$ above and we get that any such contract must satisfy (8)

[7] Note that since we have normed production costs to 0, negative prices simply means prices below the expected production costs.

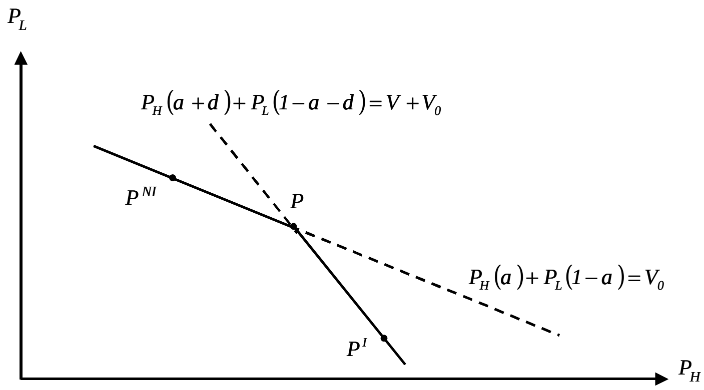

Figure 3: Pooling and Separating Contracts

with equality = and (9) with inequality < since then the non-investing producers can find better contracts. This leads to a class of contracts $(P_H^I; P_L^I)$ for investing (I) producers

$$P_H^I = V_0 - \frac{\alpha V}{\delta} + \frac{V}{\delta} + \varepsilon\frac{1}{\alpha+\delta}; \quad P_L^I = V_0 - \frac{\alpha V}{\delta} - \varepsilon\frac{1}{1-\alpha-\delta}$$

where ε is positive. Similarly, the class of contracts that only attracts non-investing producers solves (9) with equality = and (8) with inequality <. This leads to a class of contracts $(P_H^{NI}; P_L^{NI})$ for non-investing (NI) producers

$$P_H^{NI} = V_0 - \frac{\alpha V}{\delta} + \frac{V}{\delta} - \gamma\frac{1}{\alpha}; \quad P_L^{NI} = V_0 - \frac{\alpha V}{\delta} + \gamma\frac{1}{1-\alpha}$$

where γ is positive. Note that the pooling contract corresponds to the limit case where $\gamma = \varepsilon = 0$. Figure 3 illustrates the different contracts.

We see that all producers in all contracts are paid their expected values $V + V_0$ and V_0, respectively. Consequently, both processors and producers are equally well off in any separating contract and in the pooling contract. Also, the participation constraint (2) is fulfilled.

Since the producers are paid the expected value of their product, we get that a producer chooses to invest if

$$V_0 + V - c \geq V_0$$

or equivalently

$$c \cdot V \tag{12}$$

This means that the first-best investment level is achieved in the a priori competitive regime. In other words: noisy grading does not create incentive problems in a competitive environment where trade occurs before grading (as in the market for milk and the market for prunes).

Of course, these first-best levels of investment may also be reached by altering the market situation through the use of marketing or production contracts so that trade takes place before grading. This is the vertical integration solution suggested by Hennessy.

Another possibility is to have a horizontal integration of producers By forming a marketing board, the producers can make a take-it-or-leave-it offer of the first-best price plan ((10)-(11)). Note that the producers here do not form a sales coalition to get market power. In the a posteriori competitive scenario the processors already compete and the producers have the market power. The horizontal integration of producers serves however to mitigate the problems of a posteriori competition in an environment with imperfect information. By offering the first-best price plan, the loss from under-investment under a posteriori competition is eliminated.

As an example, we suggest that the horizontal integration of Californian prune growers should enable the Prune Bargaining Association to eliminate the under-utilization of the grading system caused by a posteriori competition. In our view, therefore, the analysis in Chalfant et. al. may well exaggerate the incentive problems caused by grading errors in the prune industry[8].

The a priori solution potentially suffers from enforcement problems. If a producer acquires additional information about his product before he delivers, e.g. by simply inspecting his product, he may be tempted to sell his product elsewhere, perhaps through a producer with a different contracts. Any information (in excess of whether he invested or not) can be misused by him. Moreover, it will be relatively expensive for a processor to enforce the original contract through the legal system. The processor must take legal action against each producer on an individual basis.

[8] In the model, Chalfant et. al. restrict the prices to be non-negative. This may prevent the producers from eliminating all the incentive problems. However, even if the prices must be non-negative the incentive problems are smaller under a priori competition than under a posteori competition, cf. the appendix.

In particular negative prices may cause enforcement problems.

A producer with a product graded L would be tempted not to deliver. This may however not be a feasible strategy. Firstly, in many cases the producer does not know the grade of his product before he has to deliver. For instance, a milk producer may not know the bacterial counts before delivery, cf. Hennessy. Similarly, a meat producer may not know of a salmonella infection before delivery. Secondly, testing the product may involve destruction of the tested product, cf. Chalfant et al. Thirdly, sorting the products before delivery may be too costly for the producer. Fourthly, it may be possible for the processor to monitor the producer and infer whether production has taken place or not. In our model there is no uncertainty about the quantity produced. Hence, the processor knows with certainty that the producer is cheating if he does not deliver his good.

More serious implementation problems may arise from limited liability or liquidity constraints. It may in such cases be necessary to restrict prices to be positive.

If prices, for one reason or the other, are restricted to be non-negative, it reduces the investment level. Hence a priori competition does not lead to …rst best investment levels if negative prices cannot be implemented. However, our basic result that a priori competition leads to better investment decision than a posteriori competition still holds. The details are given in the appendix.

In addition to the enforcement problems on the producer side, enforcement problems may arise with processors refusing to pay the prices promised in the original contract. These enforcement problems, however, are probably less severe because it is easy to prove whether a processor pays the promised prices and because there are alternative buyers in the market. Furthermore, there may be a problem of fraud, i.e. processors misrepresenting the testing results. Often the problem of fraud is handled by governmental monitoring of the grading process[9]. The problem of processor fraud is probably less severe under a posteriori competition than under a priori competition. The reason is that if a processor cheats on the grading, the producer can choose to sell his product to another processor when he is not tied by a long term contract.

[9] This is actually what happens in the Californian prune industry, cf. Chalfant et. al.

5 Monopsonist processor

If the processors form a horizontal integration it will affect the producers' incentives to invest. There are two possible regimes under monopsony.

The first involves a posteriori trading where the trading terms are settled after the investment. In this situation the monopsonist processor will make a classic hold-up of the producers, who cannot sell their products to others. This means that the monopsonist processor will offer the producers a prize of zero regardless of the grade. Of course the producers will foresee this and thus decide not to invest at all. The outcome of trade after investment under monopsony is therefore a total lack of investment.

If, on the other hand, the trading terms are settled before the investment decisions are made, the monopsonist is able to motivate the producers to invest. This is the usual long term contract solution to the hold-up situation. The monopsonist processor will however induce a level of investment below the first best level (rationing). He does so to reduce the adverse selection problem, i.e. the ability of producers with low costs to claim high costs and thereby extract high information rents.

The under-investment resulting from rationing can be more or less severe than the under-investment resulting from a posteriori competition. This suggests that the formation of a monopsonist regime may be preferred to (a posteriori) competition. Moreover, the enforcement problems of a long term, a priori trade contract, is probably less severe in the monopsonist setting. A producer trying to misuse new private information cannot sell his product elsewhere.

We shall now develop the monopsonist outcome in some details.

When the monopsonist offers the contract $(P_H; P_L)$, producers with costs below $c^M = \delta(P_H - P_L)$ invest and the rest do not invest. It is convenient to parametrize the monopsonist problem in terms of P_L and c^M.

The monopsonist's expected revenue on an average producer is

$$REV^M = V_0 + F\left(c^M\right)V$$

and his expected payment to an average producer is

$$
\begin{aligned}
PAY^M &= F\left(c^M\right)\left[(\alpha+\delta)P_H + (1-\alpha-\delta)P_L\right] \\
&\qquad\qquad + \left(1 - F\left(c^M\right)\right)\left[\alpha P_H + (1-\alpha)P_L\right] && (13)\\
&= F\left(c^M\right)\delta\left[P_H - P_L\right] + \alpha P_H + (1-\alpha)P_L \\
&= F\left(c^M\right)c^M + P_L + \alpha(P_H - P_L) \\
&= F\left(c^M\right)c^M + P_L + \alpha\frac{c^M}{\delta} && (14)
\end{aligned}
$$

The expected profit per producer to the monopsonist is therefore

$$\Pi = V_0 + F\left(c^M\right)V - F\left(c^M\right)c^M - P_L - \alpha\frac{c^M}{\delta} \tag{15}$$

The monopsonist maximizes this profit by choosing c^M and P_L appropriately. Of course, he must respect the defining constraint $c^M = \delta(P_H - P_L)$ and the participation constraint (2). Inserting the former into the latter, we get that the participation constraint reduces to

$$P_L \geq -\alpha\frac{c^M}{\delta}$$

Partial optimization with respect to P_L gives $P_L = -\alpha\frac{c^M}{\delta}$ and the monopsonist problem therefore reduces to[10]

$$Max_{c^M}\left[V_0 + \left(V - c^M\right)F\left(c^M\right)\right] \tag{16}$$

The first order condition for the maximization problem is

$$\left(V - c^M\right)F'\left(c^M\right) - F\left(c^M\right) = 0 \tag{17}$$

i.e. the monopsonist processor induces an investment threshold of c^M where c^M solves[11]

$$c^M = V - \frac{F\left(c^M\right)}{F'(c^M)} \tag{18}$$

---

[10] Given a solution to this, we can of course establish the optimal payment scheme using $c^M = \delta(P_H - P_L)$ and $P_L = -\alpha c^M/\delta$, i.e. as

$$P_H = \frac{c^M}{\delta}(1-\alpha); \quad P_L = -\alpha\frac{c^M}{\delta}$$

[11] This requires that $F'(c) > 0$ and that the second order condition holds:

$$(V - c)F''(c) - 2F'(c) \leq 0$$

This shows that a monopsonistic regime will induce under-investment

$$c^M < V$$

If however, the so-called hazard rate $F(:)=F^0(:)$ is not too steep, the level of investment under monopsony may be larger than the investment under a posteriori competition. Hence, a monopsonist may be socially superior to a (posteriori) competitive regime. We shall provide some examples in Section 6. We will even show that the monopsonist may be preferable to the producers as well.

Note that the optimal level of investment is independent of the quality of the information system, i.e. ® and ±. The intuition behind this is that the processor is free to choose the right span in prices to induce the wanted level of investment and then adjust P_L to match the participation constraint. By risk neutrality, the noise and associated use of more high powered schemes is not costly[12].

The results in this section rely on the use of a negative price for products graded L. As discussed in Section 4, negative prices may cause enforcement problem. If the monopsonist cannot enforce a contract with a negative price, he will induce a lower level of investment. However, a monopsony may still lead to more investment than a posteriori competition. The details are outlined in the appendix.

6 Numerical examples

To illustrate the di¤erent levels of investment in the di¤erent competitive regimes, we consider a case where c is uniformly distributed in the interval $[0;1]$ i.e. $F(c) = c$ and $F^0(c) = 1$. Furthermore we assume that $V = 1$, $V_0 = 0$, ® = 0:3 and ± = 0:5. Hence, the …rst-best outcome is $c^{FB} = 1$.

---

i.e. $F(c)$ can not be "too convex". If these requirements are not met, the level of investment will be $c = 0$.

Equaltion (18) is a classical condition for investment problems where there is no noise in the observation of investment amount but asymmetric information about investment cost, cf for example Antle and Eppen(1985). As proved above, it extends to cases with noise in the observation of the investment amount, i.e. with moral hazard as well.

[12] This implies that the monopsonist processor does not have incentives to invest in better grading systems. The same is true for the processors in the a priori competitive regime. On the other hand, the individual processors have incentives to improve their information systems under a posteriori competition.

In this case, a posteriori competition will lead to investment if $c \leq c^{CO}$, where c^{CO} according to (7) solves

$$c^{CO} = 0.5\left[\frac{c^{CO}(0.5+0.3)}{0.3+0.5c^{CO}} - \frac{c^{CO}(1-0.3-0.5)}{1-0.3-0.5c^{CO}}\right] 1$$

i.e.:

$$c^{CO}\left(-0.08+0.9c^{CO}-0.5\left[c^{CO}\right]^2\right) = 0$$

The polynomial has roots $\{0; 0.0938; 1.7062\}$ hence $c^{CO} = 0.0938$[13].

In the monopsonistic regime the investment threshold will be (using (18))

$$c^M = 1 - \frac{c^M}{1} \;\Leftrightarrow\; c^M = 0.5$$

Hence with the given parameter values, posteriori competition causes more distortion in the investment than monopsony with a priori price settling.

If the grading system changes so that $\alpha = 0.1$ and $\delta = 0.8$; the competitive investment level will change to (again using (7))

$$c^{CO} = \left[\frac{0.9c^{CO}}{0.1+0.8c^{CO}} - \frac{0.1c^{CO}}{0.9-0.8c^{CO}}\right] 0.8$$

with roots $\{0; 0.625; 1.375\}$, i.e. investment in the competitive context increases to $c^{CO} = 0.625$. The monopsonistic outcome does not depend on the quality of the information system, i.e. $c^M = 0.5$ as before. Hence, with these parameter values, competition leads to better investment decisions.

It may seem counter-intuitive that the producers can be better off if the regime is monopsonistic rather than competitive, but it is nevertheless the case. The average payment to the producers under monopsony is $PAY^M = F(c)\,c$ (as can be argued directly or derived by inserting $P_L = -\alpha\frac{c^M}{\delta}$ into (14)). In the case of uniform distribution $c \sim [0;1]$; the expected payment

[13] By the analysis in Section 3, investment takes place for all c less than or equal to the right hand side of (7). This corresponds to the condition

$$c^{CO}\left(-0.08+0.9c^{CO}-0.5\left[c^{CO}\right]^2\right) \leq 0$$

and the left, non-zero solution is therefore the relevant solution.

to a producer is: $PAY^{M} = 0.5^2 = 0.25$. The average investment cost for the fraction $F\left(c^{M}\right)$ of producers investing is $\frac{c^M}{2}$. This gives an average investment cost per producer of $F\left(c^{M}\right)\frac{c^M}{2} = c^M\frac{c^M}{2} = 0.125$; and the average profit per producer becomes $\pi^M = 0.25 - 0.125 = 0.125$ irrespectively of the characteristics of the information system. In the competitive regime the average payment per producer PAY^{CO} is

$$\begin{aligned} PAY^{CO} &= F\left(c^{CO}\right)\left[(\alpha+\delta)P_H + (1-\alpha-\delta)P_L\right] \\ &\quad + \left(1 - F\left(c^{CO}\right)\right)\left[\alpha P_H + (1-\alpha)P_L\right] \\ &= \left[F\left(c^{CO}\right)\delta + \alpha\right](P_H - P_L) + P_L \end{aligned}$$

Rewriting this using (1) and (6) reduces the expression to

$$\begin{aligned} PAY^{CO} &= F\left(c^{CO}\right)c^{CO} + \frac{\alpha}{\delta}c^{CO} + P_L \\ &= F\left(c^{CO}\right)c^{CO} + \frac{\alpha}{\delta}c^{CO} + V_0 + \frac{F\left(c^{CO}\right)(1-\alpha-\delta)}{1-\alpha-\delta F\left(c^{CO}\right)}V \end{aligned}$$

If we use the numbers of the first case ($\alpha = 0.3$, $\delta = 0.5$ and $c^{CO} = 0.0938$), the producers will obtain an average payment of 0.0938[14]. The average investment cost per producer is $F\left(c^{CO}\right)\frac{c^{CO}}{2} = 0.0044$ and the average profit per producer is therefore $\pi^{CO} = 0.0938 - 0.0044 = 0.0894$. In the second case ($\alpha = 0.1$, $\delta = 0.8$ and $c^{CO} = 0.625$) the producers obtain an average payment of 0.6250 and have average investment cost of $F\left(c^{CO}\right)\frac{c^{CO}}{2} = 0.1953$, this gives an average profit per producer of $\pi^{CO} = 0.4297$.

Comparing π^M and π^{CO}; we see that the producers may be either better off or worse off in a competitive regime compared to a monopsonistic regime.

In the figures below we have evaluated the monopsonistic and the competitive regimes for all values of α and δ. We use the same assumptions as in the examples above.

Figure 4 shows the values of α and δ[15] where a monopsony (with long term contracts) leads to higher investment than a posteriori competition. We

[14] Note that the average payment corresponds to the cost threshold (i.e. the cost level, above which no producers invest) in the uniform case considered here. This is intuitively obvious since $F\left(c^{CO}\right) = c^{CO}$ is the fraction investing. Each investing producer generates a value of $V = 1$, and competition forces the processors to pay expected value.

[15] Note that $\alpha + \delta \leq 1$ by definition, since $\alpha + \delta$ is the probability of a good being graded as H if the producer has invested.

see that this is the case when the grading system is relatively noisy, i.e. has low ±[16]. The intuition is that a noisy grading system increases the under-investment under competition caused by the necessity to pay expected value given the grading result. A more noisy grading system, on the other hand, does not a¤ect the rationing under monopsony, cf. above.

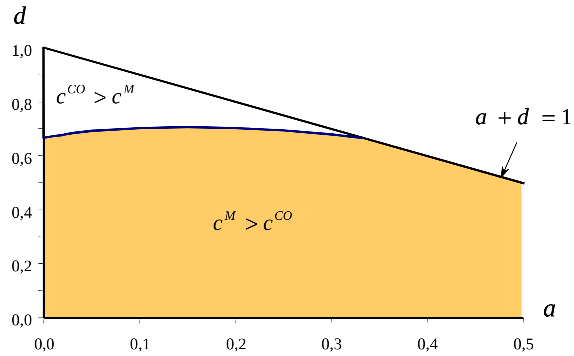

Figure 4: Region where $c^M > c^{CO}$

Figure 5 shows the values of ® and ± where the producers earn higher pro…ts in a monopsonistic regime with long contracts than in a competitive regime with a posteriori trade. The …gure shows that monopsony is preferred when the quality signal is relatively noisy, i.e. ± is small. Observing grade H is a strong indication of investment, when ® is low. I.e. for small values of ®, even small values of ± su¢ces to make H a precise indication of investment. Therefore, competition works well even though the grading is noisy.

[16] The curvature of the boarder line can be understood as follows. When ® is low, observation of grade H is a clear signal of investment. This means that a relatively small ± is su¢cient to give incentives under competition. On the other hand, when ® + ± is close to one observing grade L is a clear signal of no investment. This explains why smaller ± is su¢cient to give proper incentives, when ® increases above a certain level.

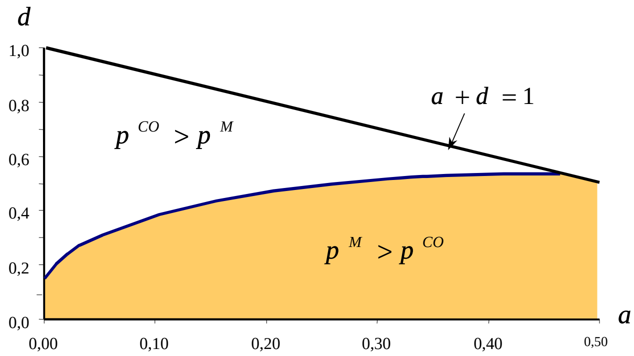

Figure 5: Region where $¼^{M} > ¼^{CO}$

If the quality of the information system is too low, there will be no investment under a posteriori competition. Figure 6 shows the values of ® and ± where this hold.

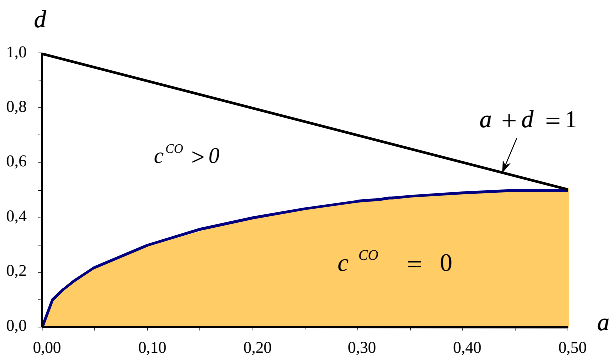

Figure 6: Region where $c^{CO} = 0$

7 Conclusion

In this paper, we have illustrated how competition may cripple the use of a noisy information system for incentive purposes.

Disregarding risk sharing concerns because of the mutual risk neutrality, …rst-best implementation is possible if the information system is just slightly informative. This requires, however, that the processors compete before the revelation of signals - a priori competition. In such cases, we can simply use more high powered incentives to compensate for the lack of reliable information. This contradicts previous claims in the agricultural economics literature on grading.

With competition after grading - a posteriori competition - the need to pay expected values of each grade makes it impossible to motivate first-best investment choices. The reason is that payment of expected values does not allow sufficiently high powered incentive schemes.

A monopsonist trading after the investment cannot induce any investment because of the hold-up problem that the producers face. A monopsonist using long term contracts can avoid the hold-up problem. To save on information rents, he will however ration the producers that are induced to invest.

Enforcement of long term contracts are easier under monopsony than competition. One reason for this is that a producer acquiring additional information before grading would be tempted to sell his products outside the contract - and that such contract breaches may be hard to observe and penalize. We suggest therefore that the most relevant comparison is between a priori monopsony and a posteriori competition.

Our main finding is now that a monopsonist regime may be superior to a competitive one. The loss from rationing introduced by a monopsonist may be more than offset by the increase in investment caused by its ability to use a more high powered payment plan. Hence, it may be socially advantageous to induce the processors to collude. A monopsonist may also be favorable to producers since their profits may be higher in a monopsonist regime than in a competitive one.

Although this is a simple set of observations, they seem to have many potential applications. In particular, they may rationalize horizontal and vertical integrations simply because such integrations reduce competition and thereby allow for stronger incentives. They may also explain why it is common in agricultural markets that grading takes place at the processors with trading terms settled before the actual grading.

Our findings can - at least in principle - be made subject to empirical tests. One of the hypotheses of our model is that investments under a priori competition are higher than under a posteriori competition. Another is that there will be more a priori trading in markets with noisy grading compared to markets with precise grading. A third is that monopsony is more likely when grading is imprecise. In practice - of course - it may be difficult to verify such hyphothesis. In the great scheme of determinants of market structure, grading issues may not be so important to be detectable.

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8 Appendix

This appendix generalizes our findings above by introducing i) restrictions on prices and ii) more elaborate grading systems.

8.1 Non-negative prices

8.1.1 A priori competition

When the processors operate under the restriction that $P_L \geq 0$, they are forced to choose $P_L = 0$ if $V_0 - \frac{\alpha V}{\delta} < 0$. This means that P_H is the only price parameter in the contract. Hence, separating equilibria cannot be implemented when $P_L \geq 0$ binds.

When $P_L = 0$ all producers with $c \leq \delta P_H$ invest, i.e. $F(\delta P_H)$ of the producers invest.

The competition among the processors forces them to pay out the expected value of the products

$$F(\delta P_H)[\alpha + \delta] P_H + (1 - F(\delta P_H))\alpha P_H = V_0 + F(\delta P_H) V$$

corresponding to[17]

$$P_H = \frac{F(\delta P_H) V + V_0}{F(\delta P_H)\delta + \alpha} \tag{19}$$

[17] If a producer offers $P_H < \frac{F(\delta P_H)V+V_0}{F(\delta P_H)\delta+\alpha}$ he will not attract any trade. If a processor offers $P_H > \frac{F(\delta P_H)V+V_0}{F(\delta P_H)\delta+\alpha}$ he will attract all trade. However, the trade will not be profitable since the payment exceeds the expected value of the products. Hence, $P_H = \frac{F(\delta P_H)V+V_0}{F(\delta P_H)\delta+\alpha}$.

First best investments are induced if $P_H = \frac{V}{\delta}$. When $P_L \geq 0$ is binding (because $V_0 - \frac{\alpha V}{\delta} < 0$) a priori competition leads to under-investment, since $P_H < \frac{V}{\delta}$. To see this, we substitute $V_0 < \frac{\alpha V}{\delta}$ into (19)

$$P_H < \frac{F(\delta P_H)V + \frac{\alpha V}{\delta}}{F(\delta P_H)\delta + \alpha} = \frac{V}{\delta}$$

A priori competition generates a higher P_H than a posteriori competition when P_L must be non-negative. This means that the price span $(P_H - P_L)$ is larger under a priori competition (because $P_L \geq V_0 \geq 0$ under a posteori competition). Thus, a priori competition generates more investment than a posteriori competition. To see this note that

$$\frac{F(\cdot)V + V_0}{\delta F(\cdot) + \alpha} > V_0 + \frac{F(\cdot)(\alpha + \delta)}{\delta F(\cdot) + \alpha}V$$

is equivalent to

$$F(\cdot)V\left[1 - (\alpha + \delta)\right] + V_0\left[1 - (F(\cdot)\delta + \alpha)\right] > 0$$

which always holds, since $\alpha + \delta \leq 1$.

8.1.2 Monopsony

When the monopsonist cannot use negative prices (i.e. $P_L = 0$), his profit is given by

$$\pi^M = V_0 + F\left(c^M\right)V - F\left(c^M\right)P_H[\alpha + \delta] - \left[1 - F\left(c^M\right)\right]\alpha P_H$$

Using $c^M = \delta P_H$ the profit to the monopsonist reduces to:

$$\pi^M = V_0 + F\left(c^M\right)V - F\left(c^M\right)c^M - \frac{\alpha c^M}{\delta}$$

The first order condition for an optimal c^M is

$$\frac{d\pi^M}{dc^M} = F'\left(c^M\right)V - F'\left(c^M\right)c^M - F\left(c^M\right) - \frac{\alpha}{\delta} = 0$$

or equivalently

$$c^M = V - \frac{F\left(c^M\right) - \alpha/\delta}{F'(c^M)}$$

Hence, introducing the restriction $P_L \geq 0$ reduces the investment level under monopsony. However, if the hazard rate $F(.)/F'(.)$ is not too steep and α/δ is small, the level of investment under monopsony may be larger than the investment under a posteriori competition. A the system becomes more informative due to higher δ or lower α, the level of investment increases.

8.2 n-grades

Consider a grading system where the probability of obtaining grade i is α_i if the producers has invested and β_i if the producer has not invested

	1	$\ldots$	n
No Inv	α_1	$\ldots$	α_n
Inv	β_1	$\ldots$	β_n

In particular, $\sum_{i=1}^{n} \alpha_i = \sum_{i=1}^{n} \beta_i = 1$.

A producer will investment if

$$c \leq \sum_{i=1} P_i(\alpha_i - \beta_i) \tag{20}$$

The participation constraint for non-investors is

$$\sum_{i=1} P_i \beta_i \geq 0 \tag{21}$$

The participation constraint for investors is

$$\sum_{i=1} P_i \alpha_i - c \geq 0 \tag{22}$$

This always holds if (21) holds since $c \leq \sum_{i=1}^{n} P_i(\alpha_i - \beta_i)$, i.e. the only relevant participation constraint is (21).

8.2.1 A posteriori competition

Under a posteriori competition the competition among processors forces them to pay the expected value of a good given its grade, i.e.

$$P_i = V_0 + \frac{F(c)\alpha_i}{F(c)\alpha_i + (1 - F(c))\beta_i} V$$

Given these prices, the cost threshold becomes

$$\begin{aligned} c^{CO} &= \sum_{i=1} P_i(\alpha_i - \beta_i) \\ &= \sum_{i=1} \left(V_0 + \frac{F(c)\alpha_i}{F(c)\alpha_i + (1 - F(c))\beta_i} V \right)(\alpha_i - \beta_i) \\ &= V \sum_{i=1} \alpha_i \frac{F(c)(\alpha_i - \beta_i)}{F(c)(\alpha_i - \beta_i) + \beta_i} \end{aligned}$$

Using $\frac{F(c)(\alpha_i - \beta_i)}{F(c)(\alpha_i - \beta_i) + \beta_i} \leq 1$ for all i and $\frac{F(c)(\alpha_i - \beta_i)}{F(c)(\alpha_i - \beta_i) + \beta_i} < 1$ for at least one i gives us

$$c^{CO} = V \sum_{i=1} \alpha_i \frac{F(c)(\alpha_i - \beta_i)}{F(c)(\alpha_i - \beta_i) + \beta_i} < V$$

and hereby

$$c^{CO} < c^{FB} = V$$

Hence, a posteriori competition leads to under-investment.

8.2.2 A priori competition

Under a priori competition, the processors must pay the expected value of the good. Hence, producers who have invested must receive an expected payment of $V_0 + V$, i.e.

$$\sum_{i=1} P_i \alpha_i = V_0 + V \tag{23}$$

Producers who have not invested should obtain an expected price of V_0, i.e.

$$\sum_{i=1} P_i \beta_i = V_0 \tag{24}$$

A processor offering a pooling contract must determine n prices satisfying the two equations (23) and (24). The solution to this problem is a hyperplane with dimension $n - 2$. In addition to these pooling contracts there are a number of separating contracts located on hyperplanes of dimension $n - 1$ satisfying either (23) or (24).

Both the pooling and the separating contracts give the producers incentives to chose the first-best investment levels since the expected payment to a producer is $V_0 + V$ if he invest and V_0 if he does not invest.

8.2.3 Monopsonist

The profit to the monopsonist is given by

$$
\begin{aligned}
\pi^M &= V_0 + F\left(c^M\right)V - F\left(c^M\right)\sum_{i=1} P_i\alpha_i - \left[1 - F\left(c^M\right)\right]\sum_{i=1} P_i\beta_i \\
&= V_0 + F\left(c^M\right)V - F\left(c^M\right)c^M - \sum_{i=1} P_i\beta_i
\end{aligned}
$$

Using the defining constraint (20) and the participation constraint (21) the profit to the monopsonist reduces to

$$
\pi^M = V_0 + F\left(c^M\right)V - F\left(c^M\right)c^M
$$

The first order condition for optimal c^M is

$$
c^M = V - \frac{F\left(c^M\right)}{F'(c^M)}
$$

which is exactly what we get for $n = 2$ (cf. (18)).

Part 3.

Discrimination and Group Division in Tournaments

Part 3.

Discrimination and Group Division in Tournaments

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Abstract

The contracts we consider in this paper must solve three problems: moral hazard, insurance and discrimination. The moral hazard problem is that of motivating the agents to take the optimal unobservable actions. The insurance problem is that of reducing the cost of risk through risk minimization and risk sharing. The issue of discrimination is that of paying agents who have superior abilities sufficient to participate, without over-compensating other agents. We show how the principal can benefit by dividing the agents into different groups. The optimal number of groups, from the principal's point of view, is determined through a trade-off between moral hazard, insurance and discrimination issues.

1 Introduction

In this paper we study a setup, where a principal contracts with a number of heterogeneous agents. The principal is forced to use only one contract for all agents (for reasons explained below). We demonstrate that in this set-up the principal can use tournaments to extract quasi-rents from the agents. We also study the role of group composition in tournaments. The ability to extract quasi-rents through tournaments may explain why producers often resist the use of tournaments in agricultural contracts, cf. Tsoulouhas and Vukina (2001).

The analysis is restricted to linear cardinal tournaments, where the agents are compensated according to their relative performance. The relative performance of an agent is determined by comparing his performance to the average performance in his group. In cardinal tournaments the payment depends on by how much the agent wins or loses the tournament. In ordinal tournaments the payment depends only on the ranking of the agents.

The literature indicate four general advantages of using tournaments instead of linear piece rate contracts[1].

Shleifer (1983) rationalizes tournaments (or more precisely yardstick competition) as a way of motivating …rms to reveal private information about production cost etc. Bogetoft (1997) extends this approach by combining Data Envelopement Analysis and tournaments. This enables him to handle more general cost and production structures than the simple linear ones usually considered.

Holmström (1982) shows how cardinal tournaments can extract information about common risk. According to Holmström tournaments serve as an insurance instrument, where common risk is shifted from the agent to the principal, "forcing agents to compete with each other is valueless if there is no common underlying uncertainty" (p. 335). This argument is also used by Knoeber (1989) to explain the use of tournaments in broiler contracts. Lazear and Rosen (1981) and Green and Stokey (1983) have shown that ordinal tournaments are valuable only when they o¤er information about common uncertainty.

Lazear and Rosen (1981) and O'Kee¤e et. al. (1984) argue that tournaments have an information cost advantage over piece rate contracts. In an ordinal tournament, information about the ranking of the agents is suf-

[1] Tournaments may also create ine¢ciencies. First, the agents have an incentive to collude and a agree that everyone shirk. This does not a¤ect the total payment to the agents, but reduces the agent's costs (Milgrom and Roberts, 1992). Second, tournaments may encourage sabotage activities because the payment to an agent is negatively correlated to the performance of other agents. This means that an agent can increase his payment by sabotaging other agents (Lazear, 1989).

ficient. Piece rate contracts require absolute information about the agents' performance. It may be cheaper to obtain and report information about the ranking of the agents than absolute information about their performances.

Bogetoft (1994), Milgrom and Roberts (1992) and Tsoulouhas (1999) argue that tournaments can reduce two-side moral hazard problems. Two-sided moral hazard problems arise if both parties perform hidden actions or if the contract is based on non-verifiable information, which the principal may not report truthfully. If the total payment to the agents is a fixed amount, the principal does not have an incentive to distort the non-verifiable information or to take inefficient actions.

This paper focuses on another feature of tournaments: the ability to discriminate the agents. The issue of discrimination is that of paying agents with different abilities sufficient to participate, without overcompensating other agents. Our model combines the moral hazard, insurance and discrimination problems. The moral hazard problem is that of providing the agents with incentives to perform in a way that maximizes the profit to the principal, when the agent's actions are not observable. The insurance problem is that of minimizing the cost of risk through risk minimization and risk sharing.

Usually discrimination problems arise in adverse selection contexts, where the principal does not know the true types of the agents. In this paper we analyze a different situation where the principal knows the agent's type but is unable to use this information directly in the contract (for reasons explained below). This forces the principal to compensate all agents according to the same rule, such that the payment depends on outcome only and not on the agent's type.

When the principal can only use one contract, he will face a trade-off: the incentives that induce the efficient level of effort may not induce perfect discrimination. Hence, either the agents will provide sub-optimal effort or they will obtain quasi-rents. We will show that the principal often distorts the level of effort in order to save on the agents' quasi-rents. The main result of this paper is that the distortion in the level of effort can be reduced if the principal divides the agents into more groups[2].

The discrimination problem arises because the agents are heterogeneous in two dimensions: abilities and reservation value. There are several reasons

[2] O'Keeffe et. al. (1984, p. 33) suggest a similar result (without proof): "[contests] may allow a the monopsonist to extract some or all of the employee's surplus on inframarginal effort units". This is in fact, what we show in this paper.

why agents may have different abilities. The agents may use different technologies, have different education or different age. Olesen (2001) studies the contract for production of green peas for Danisco Foods. In this contract the difference in abilities can be thought of as difference in soil quality. Empirical evidence suggest that the producers of broilers have significantly different abilities (Knoeber and Thurman, 1995).

Agents with different abilities will naturally have different outside opportunities and thus different reservation values. Normally high-ability agents have higher reservation value than low-ability agents. Previous studies of tournaments in agricultural contracts either assume that the agents are homogeneous (e.g. Tsoulouhas and Vukina (1999, 2001)) or that the agents have the same reservation value even though they have different abilities, cf. Goodhue (2000). The traditional literature on tournaments allows for differences in the reservation value by assuming perfect competition on the labor market, such that each agent must be paid the expected value of what he produces, cf. Lazear and Rosen (1981), Green and Stokey (1983) and O'Keeffe et. al. (1984).

In this paper we assume that the principal has monopsony power. Hence, the payment must reflect outside opportunities - often in a entire different production. This means that the reservation values of agents with different abilities is not directly determined by the difference in the value of what they produce (even though there is typically positive correlation).

When the agents are heterogenous and the principal knows the agents' type, the optimal tournament involves handicapping or sorting of the agents into internally homogeneous groups offered different payment schemes[3] (Lazear and Rosen, 1981). O'Keeffe et. al. (1984) shows how a principal can solve the moral hazard and adverse selection problems (when the principal does not know the agents' type) simultaneously by varying monitoring precision and the price spread in the tournament. Similarly, Clark and Riis (2001) shows how a tournament system with sequential testing can solve the moral hazard and adverse selection problems, such that each agent selects the proper contract. These solutions all require that the principal can use different contracts for different agents. However, in many cases this is not realistic. Several circumstances may prevent the principal from using a menu of contracts.

Firstly, the agents may possess some bargaining power and, through col-

[3] Knoeber and Thurman (1994) finds empirical evidence of handicapping and sorting in broiler contracts based on rank-order tournaments.

lective bargaining, force the principal to only use one contract. If the principal is prevented from using di¤erent payment schemes to di¤erent agents, the principal may be forced to raise the payment to all agents in order to attract a particular type of agent. An example of this situation is the contract production of green peas for Danisco Foods. Due to e¢ ciency considerations, the …rm wants to use its limited capacity to contract with the growers on the best soils. The growers, however, have blocked the use of bonuses for growers with high soil quality through collective bargaining. This enables the growers to extract information rent, cf. Olesen (2001).

Secondly, legal restrictions such as anti discrimination clauses may prevent the principal from using all available information directly in the contract. This may force the principal to o¤er the same payment scheme to all agents.

Finally, transaction costs may give the principal incentives to simplify the contracts, see e.g. Milgrom and Roberts (1992). A simple contract may reduce the number of disputes. For instance, if the contract is independent of the agent's type, the parties will not spend time discussing the agent's abilities. Individualized contracts increases the number of negotiations. Therefore, in many cases it will be cheaper for the principal to use only one contract.

The principal will often have the authority to determine the group composition, even though he is prevented from using di¤erent contracts. The group composition often depends on the organization of the production, which is typically determined by the principal. In the contract for production of green peas for Danisco Foods the group division is done according to the time of sowing, which is determined by the principal (Olesen, 2001). In the US broiler production the group composition depends on the trucking route, which is determined by the principal (Knoeber and Thurman, 1995). In …rms using internal tournaments[4] to motivate the employees, the group composition depends on the …rm size and the number of divisions in the …rm. Again these aspects are typically determined by the principal.

The outline of the paper is as follows: A description of our basic model is given in Section 2. In Section 3 we introduce the insurance and the moral hazard issues. In Section 4, we introduce the discrimination issue and solve the principal's problem when all agents compete in one group. In Section 5 we analyze how the principal prefers to divide the agents. We consider

[4] E.g. career contests as in Lazear and Rosen (1981) and O'Kee¤e (1984) or sales contest, c.f. Kalra and Shi (2001).

the case of internally heterogenous groups in section 5.1, where every group includes both high and low-ability agents. In Section 5.2 we address the question: how many groups does the principal prefer? In Section 5.3 we discuss linear yardstick contracts. Section 6 concludes the paper.

2 The Model

We analyze a case where a principal contracts with two types of agents, high-ability agents with high reservation value and low-ability agent with low reservation value. In this setting, the low-ability agents expect to lose a tournament with high-ability agents and receive a lower payment than high-ability agents. However, a low-ability agent wants to participate as long as the profit he receives exceeds his reservation value.

We consider a principal contracting with n agents. The principal earns p on each unit produced. The production of agent i is given by a simple additive function

$$y_i = e_i + a_i + \varepsilon_i + \mu \tag{1}$$

where e_i is agent i's unobservable effort, a_i is the ability of agent i. The output is affected by two independent random variables. The random variable $\mu \sim N(0; \Sigma^2)$ is a general disturbance affecting all agents, and ε_i is a disturbance factor affecting only agent i (idiosyncratic risk), ε_i is independent identically distributed $N(0; \sigma^2)$.

For convenience, we assume that there are only two types of agents, n_H agents with high abilities (a_H) and n_L agents with low abilities (a_L), where $a_H > a_L$. We assume that it is always optimal for the principal to contract with all agents. We also assume that $n_L = n_H = \frac{n}{2}$, this symmetry enables us to normalize our model with $a_L = -\theta$ and $a_H = \theta$, giving average abilities of zero.

The agents are compensated according to a linear tournament given by

$$x_i = t + \beta(y_i - \bar{y}) \tag{2}$$

I.e., the agent is paid a base transfer t; common to all agents, plus a reward-factor β times the relative performance, measured by his deviation from the average performance of the group $\bar{y} = \frac{1}{n}\sum_{j=1} y_j$:

We assume that the cost of effort is

$$\psi(e_i) = \frac{1}{2}e_i^2$$

Furthermore, we assume that the principal is risk neutral and that the agents are risk averse and have a utility function of the form

$$u_i(x_i; e_i) = -\exp(-r[x_i - \psi(e_i)])$$

where r is the absolute risk aversion, common to all agents, and x_i is the payment to agent i.

Using the properties of the distribution of the uncertainty and the negative exponential utility function, the utility can be expressed in terms of certainty equivalence[5]

$$CE_i(x_i; e_i) = E(x_i) - \psi(e_i) - \frac{1}{2}\beta^2 rVar(x_i)$$

The principal can observe neither the effort nor the uncertainty parameters, i.e. $e; \mu; \varepsilon_i$. He observes the ability a_i, but cannot use this information directly in the payment scheme.

The payment to agent i, determined by the tournament, is

$$x_i = t + \beta[(a_i - \bar{a}) + (e_i - \bar{e}) + (\varepsilon_i - \bar{\varepsilon})]$$

where $\bar{a}$, $\bar{e}$, and $\bar{\varepsilon}$ are defined in the same way as $\bar{y}$. Note that $\bar{a} = 0$ due to our normalization. Note also that the tournament removes the common risk μ from the payment. This enables the principal to insure the agents against common risk, cf. Holmström (1982).

The certainty equivalence of agent i is

$$CE = t + \beta[a_i + (e_i - \bar{e})] - \frac{1}{2}e_i^2 - \frac{1}{2}\beta^2 rVar(\varepsilon_i - \bar{\varepsilon}) \qquad (3)$$

The principal chooses the contract parameters t (base transfer) and β (reward-factor) to maximize his profit under two constraints.

The first constraint is that the agents must benefit (weakly) from participating. This is the individual rationality constraint (IR). Each agent has an outside opportunity giving him a certainty equivalence of $\bar{u}(a_i)$. We assume

[5] See for instance Holmström and Milgrom (1991) for a similar modelling approach.

that $\bar{u}(a_H) \geq \bar{u}(a_L)$, thus the principal must pay more to the high-ability agents. Without loss of generality[6], we normalize the measure of the reservation values such that $\bar{u}(a_L) = -w$ and $\bar{u}(a_H) = w$. Hence, the average reservation utility is zero.

The second constraint is that the agents choose their efforts to maximize their own utilities. This is the incentive compatibility constraint (IC).

The principal's problem is[7]

$$\max_{e;t;\beta} \Pi = E\left(p \sum_{i=1}^{n} y_i - nt\right)$$

$$\text{s.t.}$$

$$CE_i(e_i) \geq CE_i(e_i') \quad \text{for all } i; e' \tag{IC}$$

$$CE_i(e_i; a_i) \geq \bar{u}(a_i), \qquad a_i \in \{a_L; a_H\} \tag{IR}$$

The IC constraint is fulfilled, when the certainty equivalence is maximized. By concavity of the certainty equivalence, the sufficient first order condition is

$$\frac{\partial CE_i}{\partial e_i} = \beta\frac{n-1}{n} - e_i = 0$$

In optimum all agents choose the same level of effort $e_i = \beta\frac{n-1}{n}$, which is lower than the reward-factor. The reason is that the agent takes into account that if he increases his effort he also increases the mean output in his group to which he is being compared.

3 Homogeneous agents: The Moral Hazard Effect

It is useful to consider the case where all agents are identical, i.e. $a_i = 0$ for all i and $w = 0$, as a benchmark case. In this case, there is no discrimination issue. Identical agents face the same incentives and provide the same effort and therefore obtain the same expected output. Thus, the IR constraint

[6] The actual level of reservation value only affect the base transfer t. Hence, for our analysis it is sufficient to consider the relative reservation values.

[7] We use $\beta\left[\sum_{i=1}^{n}(y_i - \bar{y})\right] = 0$.

reduces to[8]

$$t \geq \frac{1}{2}e_i^2\left(1 + r\sigma^2\frac{n}{n-1}\right)$$

i.e. the base transfer must exceed the agents' cost of providing effort plus the risk premium plus the reservation value. Recall that we take the number of agents as given, hence maximizing the principal's profit is equivalent to maximizing the profit per agent. Substituting $\beta = e\frac{n}{n-1}$ (where e is the common value of e_i), and $t = \frac{1}{2}e^2 + \frac{1}{2}re^2\sigma^2\frac{n}{n-1}$ into the objective function gives

$$\max_e \frac{\Pi}{n} = pe - \frac{1}{2}e^2\left(1 + r\sigma^2\frac{n}{n-1}\right)$$

The objective function now reflects the usual moral hazard problem. To increase the effort level e the principal must expose the agents to more risk which increases the risk premium. This optimization problem has the following (sufficient) first order condition

$$e^* = \frac{p}{1 + r\sigma^2\frac{n}{n-1}} \tag{4}$$

This is a classic result in the literature; the principal does not induce the first best level of effort ($e = p$), because this would expose the agents to too much risk, see e.g. Holmström (1979) and Lazear and Rosen (1981). An increase in the variance σ^2 or the absolute risk aversion r increases cost of the risk. Thus, the principal induces a lower level of effort when σ^2 or r is high. As the number of agents increases, the risk premium decreases and the optimal level of effort increases. This is so, because the principal obtains more precise information about the effort e_i since the noise from $\bar{\varepsilon}$ can be eliminated more and more (the law of large numbers).

4 Heterogeneous agents: The Discrimination Effect

After introducing the moral hazard issue, we now consider the discrimination issue. As mentioned in the introduction, we consider situations where the

[8] The structure of the risk in our model, imply that $Var(\varepsilon_i - \bar{\varepsilon}) = \sigma^2\frac{n}{n-1}$ since ε_i is i.i.d. $N(0;\sigma^2)$.

principal is restricted to use the same t and β for all agents. Therefore, the principal can only meet the IR constraint for one type of agents by altering β and t for all agents.

The payments to the two types of agents differ due to the difference in their abilities and reservation value. The IR constraint must hold for both types of agents, i.e.

$$CE_L(e; a_L) \geq \bar{u}(a_L) \quad \text{and} \quad CE_H(e; a_H) \geq \bar{u}(a_H)$$

Using (3) these IR constraints can be written as

$$t - \mu e \frac{n}{n-1} - \frac{1}{2}e^2 \left(1 + r\sigma^2 \frac{n}{n-1}\right) \geq -w \tag{IR-L}$$

and similarly

$$t + \mu e \frac{n}{n-1} - \frac{1}{2}e^2 \left(1 + r\sigma^2 \frac{n}{n-1}\right) \geq w \tag{IR-H}$$

Notice that the high-ability agents are rewarded for their abilities and that the low-ability agents are penalized for their low abilities. Notice also that both the left- and the right-hand side of the IR constraint for the high-ability agents are larger than for the low-ability agents. Thus, either of the constraints can be binding in a given situation.

The optimal base payment t depends on the tighter of the two IR constraints. If the IR constraint for the low-ability agents is the binding constraint (such that IR-L implies IR-H), the principal chooses

$$t = t_L = -w + \mu e \frac{n}{n-1} + \frac{1}{2}e_i^2 \left(1 + r\sigma^2 \frac{n}{n-1}\right) \tag{5}$$

and the high-ability agents earn quasi-rents. If the IR constraint for the agents with high abilities is the binding constraint, the reverse is true and the base payment is

$$t = t_H = w - \mu e \frac{n}{n-1} + \frac{1}{2}e_i^2 \left(1 + r\sigma^2 \frac{n}{n-1}\right) \tag{6}$$

Our model does not tell per se which of the IR constraints is the tighter constraint. We therefore have three cases to consider. Case A, where the low-ability agents receive quasi-rents. Case B, where the high-ability agents receive quasi-rents. And finally Case C, where none of the agents receive quasi-rents.

4.1 Case A: quasi-rents to low-ability agents

We now consider the situation where the payment exactly satisfies IR-H, such that high-ability agents receive no quasi-rents. We use that $\beta = e\frac{n}{n-1}$ and $t = t_H$. We denote the level of effort in this setting e^H. The principal maximizes his profit per agent

$$\frac{\pi^H}{n} = \max_{e^H} \left[pe^H - \frac{1}{2}\left(e^H\right)^2 \left(1 + r\sigma^2 \frac{n}{n-1}\right) - \left(w - \theta e^H \frac{n}{n-1}\right) \right]$$

$$s.t.: w \geq \theta e^H \frac{n}{n-1}$$

The constraint $w \geq e^H \theta \frac{n}{n-1}$ ensures that the IR-L is fulfilled. In Case A IR-L is not binding. If both IR-H and IR-L bind, none of the agents receives quasi-rents (Case C).

The first order condition[9] for maximum profit generated by one agent is

$$\frac{d\pi^h(e)}{de^H} = p - e^H - \underbrace{e^H r\sigma^2 \frac{n}{n-1}}_{\text{moral hazard effect}} + \underbrace{\theta \frac{n}{n-1}}_{\text{discrimination effect}} = 0$$

$\Leftrightarrow$

$$e^H = \frac{p + \theta\frac{n}{n-1}}{1 + r\sigma^2\frac{n}{n-1}} \tag{7}$$

The first order condition shows that the discrimination effect $\theta\frac{n}{n-1}$ is positive[10]. I.e. the principal induces a higher level of effort in order to reduce quasi-rents to the low-ability agents. Stronger incentives means higher penalty to low-ability agents for low performance.

Figure 1 and 2 illustrate the trade-off between inducing optimal effort and discriminating the agents.

Figure 1 illustrates how the level of effort is determined. The production costs plus the risk premium is given by $\frac{1}{2}\left(e^H\right)^2\left[1 + r\sigma^2\frac{n}{n-1}\right]$. When there is no discrimination issue the optimal level of effort is e^*, which is induced by the reward-factor $\beta^* = \frac{p}{\frac{n-1}{n} + r\sigma^2}$. However, the reward-factor β^* does not ensure perfect discrimination. Therefore, the principal distort the level of effort up to e^H in and use reward-factor $\beta^H = \frac{p + \frac{n}{n-1}\theta}{\frac{n-1}{n} + r\sigma^2}$.

---

[9] The second order condition is always fulfilled, since: $\frac{d^2\pi^h}{d(e^H)^2} = -1 - \frac{n}{n-1} r\sigma^2 < 0$.

[10] A common feature of adverse selection models is that the principal distort the level of effort to reduce quasirents, see for example Laffont and Tirole (1993).

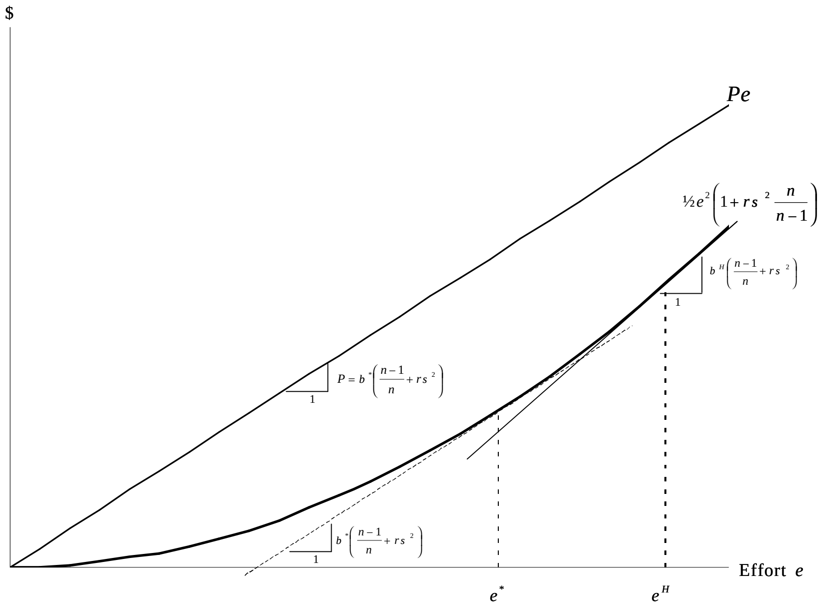

Figure 1: The Level of Effort in Case A

In Figure 2, the IR constraint for high-ability agents is fulfilled, when they receive a payment of $x = t_H(e) + \beta\theta$, cf. (6). The IR constraint for the low-ability agents is fulfilled, when they receive a payment of $x = t_L(e) - \beta\theta$, cf. (5). Increasing the effort from e^* to e^H also increase both production cost and risk premium, thus shifting the IR constraints. The payment to the low-ability agents exceed their IR constraint, i.e. they earn quasi-rents. The quasi-rents to the low-ability agents fall, when the reward-factor is increased from β^* to β^H:

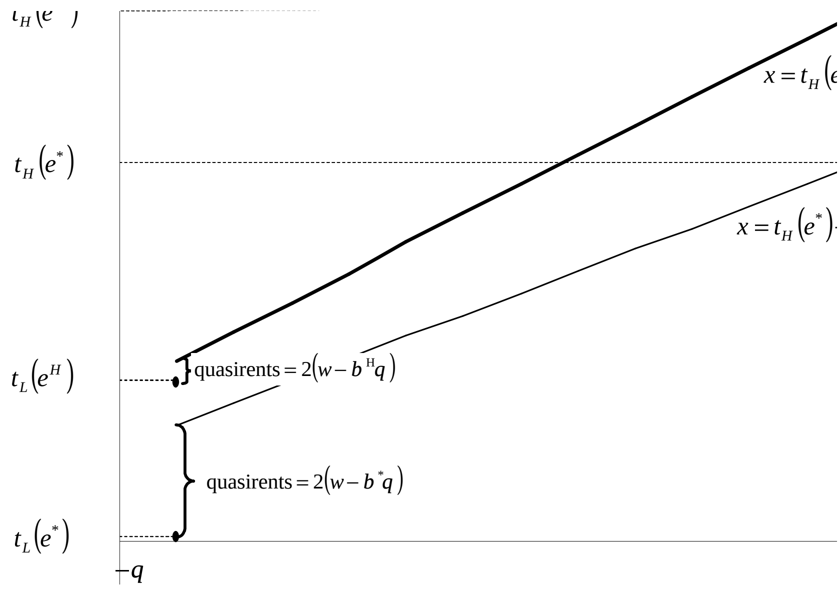

Figure 2: Quasirents to Low-ability Agents

4.2 Case B: quasi-rents to high-ability agents

Next, we consider the situation where the payment exactly satisfies IR-L, such that the low-ability agents receive zero quasi-rents. In this section we assume that the high-ability agents receive positive quasi-rents (we return to the situation where none of the agents receives quasi-rents in Case C). We denote the level of effort in this case e^L. The principal maximizes profit per agent

$$\frac{\pi^L}{n} = \max_e \left[pe^L - \frac{1}{2}\left(e^L\right)^2 \left(1 + r\sigma^2 \frac{n}{n-1}\right) - \left(w + \mu e^L \frac{n}{n-1}\right) \right]$$

$$\text{s.t.} \quad w \leq \mu e^L \frac{n}{n-1}$$

The constraint $w \leq \mu e^L \frac{n}{n-1}$ ensures that IR-H is fulfilled. In Case B, the IR-H holds with inequality, and the maximization problem has an internal solution of

$$e^L = \frac{p - \mu \frac{n}{n-1}}{1 + r\sigma^2 \frac{n}{n-1}} \tag{8}$$

When the high-ability agents receive quasi-rents, the principal induces a lower level of e¤ort, i.e. the discrimination e¤ect is negative. The reason is that reducing the incentives also reduces the bene…ts for having high abilities. The situation is illustrated in Figure 3 and 4. The Figures are designed in the same way as Figure 1 and 2 - but the problem is reversed so that the high-ability agents receive quasi-rents. Figure 3 and 4 show that reducing the incentives decreases the quasi-rents to the high-ability agents, therefore the discrimination e¤ect decreases the optimal level of e¤ort.

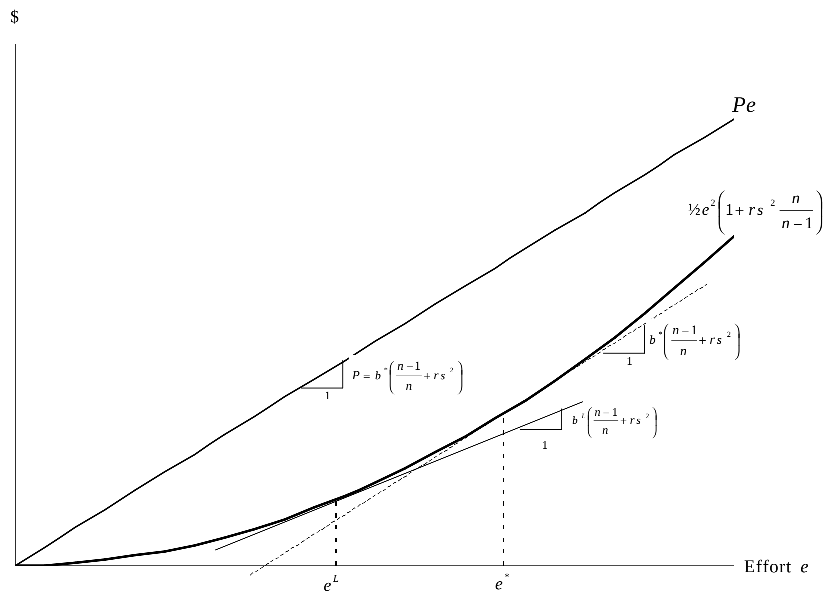

Figure 3: The Level of E¤ort in Case B

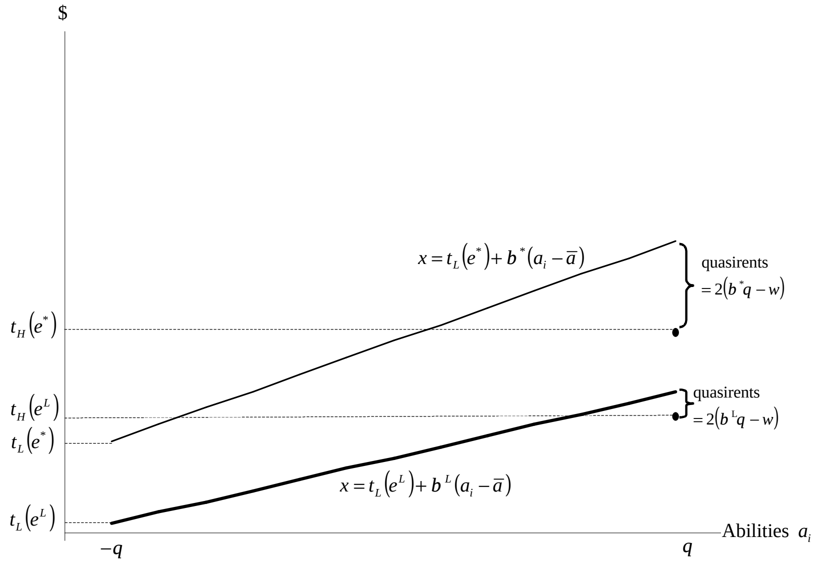

Figure 4: Quasirents to High-ability Agents

4.3 Case C: no quasi-rents

When neither Case A nor Case B applies, the principal eliminate all quasi-rents. We refer to this as Case C. The relevant interval for Case C is

$$\frac{p - \left(\frac{n}{n-1}\right)}{\frac{n-1}{n} + r\sigma^2} \le w \le \frac{p + \left(\frac{n}{n-1}\right)}{\frac{n-1}{n} + r\sigma^2} \tag{9}$$

In this interval the principal always chooses the level of effort $e^C = \frac{n-1}{n}\frac{w}{\theta}$, which induces perfect discrimination between the two types of agents, such that all quasi-rents are eliminated. In Case C there is no freedom in the choice of β and t. The principal basically has to solve two independent equations with two independent variables, hence $e^C = \frac{n-1}{n}\frac{w}{\theta}$ and $\beta = \frac{w}{\theta}$.

Outside the interval (9) there is imperfect discrimination and either Case A or Case B applies. We can summarize our finding as follows

Proposition 1 When all agents compete in one group and the principal can use one contract only, he induces the following level of effort

$$e = \begin{cases} e^H = \dfrac{p+\theta\frac{n}{n-1}}{1+r\sigma^2\frac{n}{n-1}} & \text{if } w \geq \theta e^H \frac{n}{n-1} \quad \text{(Case A)} \\ e^C = \frac{n-1}{n}\frac{w}{\theta} & \text{otherwise} \quad \text{(Case C)} \\ e^L = \dfrac{p-\theta\frac{n}{n-1}}{1+r\sigma^2\frac{n}{n-1}} & \text{if } w \leq \theta e^L \frac{n}{n-1} \quad \text{(Case B)} \end{cases} \tag{10}$$

Figure 5 maps the three different cases.

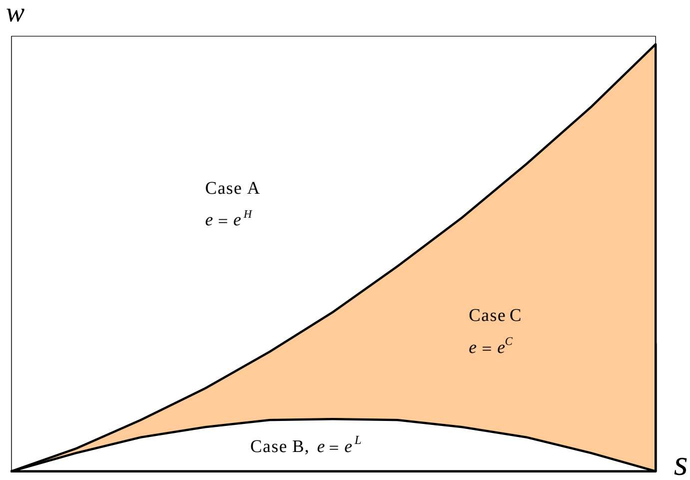

Figure 5: Mapping of case A, B and C.

Notice that $e^L < e^* < e^H$, i.e. outside the interval where no agent earns quasi-rents, the level of effort is always distorted. In the interval where no agent earns quasi-rents (Case C), the level of effort may be distorted both upwards and downwards due to the discrimination effect, i.e. $e^C \gtrless e^*$.

5 Group Division

So far, we have considered only cases where all agents compete in one group (tournament). However, the principal may use his knowledge about the agents' types and reduce the quasi-rents if he divides the agents into more than one group.

We assume that the level of effort is in interval (9) where it is optimal to discriminate perfectly between the two types of agents and eliminate all quasi-rents - i.e. Case C[11].

In this paper we only consider internally heterogeneous groups where high-ability agents are mixed with low-ability agents.

5.1 One or Two Groups?

When there is perfect discrimination, the reward-factor is $\beta = \frac{w}{\theta}$, hence the reward for having high abilities is independent of the group size. However, an agent has more impact on the average performance in his group when the group is small. This reduces the agents incentives to provide effort, thus the level of effort changes according to the size of the group. The distortion in the level of effort can both increase and decrease when the agents are divided into groups.

When the agents compete in two groups, the level of effort is

$$e^{he} = \frac{n-2}{n}\frac{w}{\theta} \tag{11}$$

The difference in the level of effort compared to the case where all agents compete in one group is

$$e^{C} - e^{he} = \frac{n-1}{n}\frac{w}{\theta} - \frac{n-2}{n}\frac{w}{\theta} = \frac{1}{n}\frac{w}{\theta} > 0$$

i.e. the level of effort is always lower if the agents compete in two groups than if all agents compete in one group.

The principal may gain by dividing the agents into two groups, if the effort induced when all agents compete in one group is distorted upwards relative to e^* (i.e. $e^C > e^*$). On the other hand, if the level of effort is distorted downwards relative to e^* when all agents compete in one group (i.e. $e^C < e^*$), dividing the group will only make things worse - for two reasons. Firstly, the level of effort is always lower when the agents compete in two groups instead of one group, i.e. the distortion in the level of effort increases when the agents are divided into two groups. Secondly, the uncertainty increases when the agents are divided into two groups. In other words, it is relevant to divide the

[11] I.e. we assume: $\frac{p - \frac{n}{n-1}\theta}{1-\frac{1}{n}+r\sigma^2}\theta \leq w \leq \frac{p + \frac{n}{n-1}\theta}{1-\frac{1}{n}+r\sigma^2}\theta$.

agents into two groups only if the level of effort is distorted upwards when all agents compete in one group (i.e. $e^C > e^*$).

When the principal divides the agents into two groups his profit per agent increases by (using (10))

$$\frac{\pi^{he}-\pi^C}{n}=\frac{w}{\theta}\left[\left(\frac{1}{2}r\sigma^2+\frac{n-\frac{3}{2}}{n^2}\right)\frac{w}{\theta}-\frac{1}{n}p\right]$$

Hence, the principal chooses to have the agents competing in

$$\begin{aligned}\text{one group if }\ w &\leq \frac{p\theta}{1-\frac{3}{2n}+\frac{1}{2}r\sigma^2}\\ \text{two groups if }\ w &> \frac{p\theta}{1-\frac{3}{2n}+\frac{1}{2}r\sigma^2}\end{aligned}\tag{12}$$

The higher the price p, the larger the interval of w (the difference in the reservation values) where the principal prefers that the agents compete in one group. The reason is that effort is more valuable if the price is high.

If the number of agents goes up, the interval where the principal prefers two groups increases. The reason is that the uncertainty only increases very little, when a large number of agents are divided into two groups. Therefore, the gain from a lower distortion in the level of effort can be obtained through a small increase in the risk premium.

Another interesting result is that high variance or high risk aversion increases the interval where the principal prefers two groups. When the agents are divided into two groups, two opposite effects come into play. Firstly, the uncertainty increases due to the law of large numbers. Secondly, the reward-factor falls from $\beta=\frac{w}{\theta}\frac{n-1}{n}$ to $\beta=\frac{w}{\theta}\frac{n-2}{n}$. The latter effect dominates the first in the risk premium (the reward-factor is raised to the second power when the risk premium is calculated). When the agents compete in two groups instead of one group, the risk premium decreases by

$$\begin{aligned}&\frac{1}{2}\left(\frac{n-1}{n}\frac{w}{\theta}\right)^2 r\sigma^2\frac{n}{n-1}-\frac{1}{2}\left(\frac{n-2}{n}\frac{w}{\theta}\right)^2 r\sigma^2\frac{n}{n-2}\\ &=\frac{1}{2}r\sigma^2\left(\frac{w}{\theta}\right)^2\frac{1}{n}>0\end{aligned}$$

This expression shows that the reduction of the reward factor more than outweighs the increase in uncertainty.

5.2 How Many Groups?

We have shown that the principal may benefit from dividing the agents into two groups. This reasoning can be repeated. The principal may prefer to have four heterogenous groups rather than just two groups and so on. In this section we address the question: what is the optimal number of groups from the principals point of view?

Let g denote the number of groups. The level of effort in the interval where no agent earns quasi-rents, Case C, is

$$e(g) = \frac{n-g}{n}\frac{w}{\theta} \tag{13}$$

The principal's profit per agent expressed as a function of g is

$$\frac{\pi(g)}{n} = pe(g) - \frac{1}{2}e(g)^2\left(1 + r\sigma^2\frac{n}{n-g}\right)$$

Solving the first order condition[12] and ignoring integer problems gives the optimal number of groups

$$g = n + \frac{1}{2}nr\sigma^2 - np\frac{\theta}{w}$$

There has to be at least one group, and each group must have at least two agents for the tournament to work. We can summarize our results as follows

Proposition 2 The optimal number of groups g is found through a trade-off between moral hazard, insurance, and discrimination issues. The trade of is given by

$$g = \begin{cases} 1 & \text{if } w \leq \frac{p\theta}{\frac{n-1}{n}+\frac{1}{2}r\sigma^2} \\ n - np\frac{\theta}{w} + n\frac{1}{2}r\sigma^2 & \text{otherwise} \\ \frac{n}{2} & \text{if } w \geq \frac{p\theta}{\frac{1}{2}+\frac{1}{2}r\sigma^2} \end{cases} \tag{14}$$

[12] The first order condition for g is: $\frac{d\pi(g)}{dg} = -p\frac{w}{\theta} + \frac{1}{n}\frac{w^2}{\theta^2}(n-g) + \frac{1}{2}r\sigma^2\frac{w^2}{\theta^2} = 0$ The second order condition for g is fulfilled since: $\frac{d^2\pi(g)}{dg^2} = -\frac{1}{n}\left(\frac{w}{\theta}\right)^2 < 0$.

The optimal number of groups is found through a trade-off between moral hazard, insurance, and discrimination issues.

When the moral hazard issue dominates due to a high price p, the principal prefers to have the agents competing in few and large groups. The reason is that the level of effort is highest in large groups.

When the discrimination effect dominates, the principal chooses to divide the agents into small groups to increase the discrimination. The discrimination issue is dominating when the difference in the reservation value (w) is large relative to the difference in the abilities (μ).

When the insurance issue dominates, the principal prefers to divide the agents into small groups. In this way he can reduce the risk premium, because the reward-factor falls. The risk premium is reduced even though the uncertainty actually increases. The reason is that the reduction of the reward-factor more than outweighs the increase in uncertainty as described in section 3.1.

5.3 Linear Yardstick Competition

An earlier version of this paper was based on a linear yardstick contract of the form $x_i = t + \beta(y_i - \bar{y}_{-i})$, where $\bar{y}_{-i} = \frac{1}{n-1}\sum_{j \neq 1} y_j$ (cf. Schleifer, 1985). I.e. the agent in question is excluded, when the norm he is being compared to is calculated. This means that the level of effort is equal to the reward factor, i.e. $e = \beta$.

In a yardstick contract the norm an agent is being compared to is biased against his own type, because $n_L = n_H$. To see this note that in a group with to agents a high-ability agent will be compared to one low-ability agent. In a group with four agents a high-ability agent will be compared to two low-ability and one high-ability agents. Hence, a high-ability agent will be compared to relatively more low-ability agents the smaller the group. This means that a high-ability agent will benefit more from his abilities in a small group. The principal can use this feature to improve the discrimination by dividing the agents into smaller groups. The difference in abilities generates a difference in the payments of

$$\beta(s_i - \bar{s}_{-i}) = \begin{cases} \mu\frac{n}{n-g} & \text{for high-ability agents} \\ -\mu\frac{n}{n-g} & \text{for low-ability agents} \end{cases}$$

This means that the results in this paper ((10) and (14)) also hold for linear yardstick contracts.

6 Conclusion

We have developed a model combining moral hazard, risk sharing, and discrimination issues in linear tournaments. We have shown that the principal can bene…t by dividing the agents into tournaments or groups when the principal posses some information about the agents' type, which he cannot use directly in the contract.

The discrimination e¤ect causes distortion in the level of e¤ort. Consider case A, when the low-ability agents receive quasi-rents. In this case, it is optimal for the principal to use stronger incentives and implement a higher level of e¤ort. Stronger incentives reduces the quasi-rents to low-ability agents via a stronger penalty. In case B, the high-ability agents receive quasi-rents. Here it is optimal for the principal to use weaker incentives. This distorts the level of e¤ort downwards and reduces the quasi-rents to the high-ability agents, since these agents bene…t less from having better abilities. In case C, where none of the agents receives quasi-rents, the discrimination e¤ect may distort the level of e¤ort either upwards or downwards.

The principal can use the division of agents into groups strategically. If the principal distorts the level of e¤ort upwards in case C, he may gain in two ways from dividing the agents into more heterogeneous groups. Firstly, the distortion in the level of e¤ort falls, since the level of e¤ort is lower in smaller groups. Secondly, the risk premium is reduced because the incentives become weaker.

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Part 4.

Single Bid Restriction in Milk Quota Exchanges – A Comparison of the Danish and the Ontario Exchanges

Part 4.

Single Bid Restriction in Milk Quota Exchanges
– Comparing the Danish and the Ontario Exchanges

by

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ABSTRACT

This paper analyzes the design of the Danish milk quota exchange. We focus on the restriction that each producer can only submit a single bid (a quantity and a price limit). We argue that this restriction creates inefficiencies for two reasons. First, a single bid cannot express a buyer's downward sloping demand curve (the aggregation effect). Second, the buyers minimize the risk of foregoing profitable trade by submitting their average valuation rather than their marginal valuation of quota (the uncertainty effect). We use data from the (multiple bids) Ontario milk quota exchange, to evaluate the empirical impact of a single bid restriction.

Keywords: Quota exchange, single bid, multi-unit, double auctions, efficient trade.

1 Introduction

The EC introduced milk quotas to reduce the supply of milk back in 1984. Since then Denmark has allowed the quotas to be traded in different ways. Until 1997, quotas were traded along with farm land and bought and re-distributed by the Danish Dairy Board. In 1997, a milk quota exchange was introduced to facilitate efficient reallocation of milk quotas and to reduce transaction costs related to the searching and matching. This paper analyzes the design of the Danish milk quota exchange.

Quota programs play an important role in agricultural policy and have generated a large literature. A number of empirical studies have computed potential efficiency gains from establishing a free market for quotas. Using simulation, Rucker et. al. (1995) calculated the deadweight loss from restrictions in the transferability of tobacco quotas in North Carolina. Ewasechko and Horbulyk (1995) and Lambert et. al. (1995) calculated potential efficiency gains from re-allocation of milk quotas across provinces in Canada. Boots et. al. (1997) estimated the cost of quantity restrictions in Dutch milk quota trade.

The theoretical literature on auctions is large as well. A recent survey is Klemperer (1999). The focus is typically on one-sided auctions, where a monopolist chooses the auction rules to maximize expected revenue. However some of the most important markets are governed by two-sided auctions, also referred to as double auctions or exchanges. Several empirical studies and laboratory experiments have shown that the double auction institution is very stable. Test auctions with as few as 2-3 buyers and 2-3 sellers have generated almost efficient outcomes (Friedman, 1984). This suggests that − if one uses an appropriate design of the auction rules − the double auction generate an efficient allocation even with very few participants.

In the Danish milk quota exchange the producers can only submit one bid each. A similar single bid restriction is found on the German milk quota exchanges (Bundesministerium für Ernährung, Landwirtschaft und Forsten, 2000). The contribution of this paper is to analyze the impact of this restriction both theoretically and empirically.

The single bid restrictions creates distortions in two ways. Firstly, a buyer cannot express a downward sloping demand curve by submitting a single bid (the aggregation effect). Secondly, the buyers try to reduce the risk of foregoing profitable trade by submitting high bids (the uncertainty effect). In a similar manner, distortions are introduced on the seller's side. The aggregation effect and the uncertainty effect lead to inefficient trade on the Danish milk quota exchange.

We also show how the efficiency of the Danish milk quota exchange can be improved by allowing the producers to submit multiple bids. This corresponds to the trading rules on the Canadian milk quota exchanges, where the producers can submit multiple bids. We use data from the milk quota exchange in Ontario to evaluate the effect of imposing a single bid restriction on a milk quota exchange. This allows us to quantify the likely distortion generated by the single bid restriction on the Danish exchange.

The remainder of this paper is organized as follows. Section 2 describes the Danish milk quota exchange. In Section 3, we analyze the effects of single bid restrictions and in Section 4, we show how the distortions on the Danish milk quota exchange can be avoided by allowing the producers to submit multiple bids. The empirical impact of a single bid restriction is evaluated in Section 5. We discuss our assumptions and results in Section 6. Section 7 concludes the paper.

2 The Danish Milk Quota Exchange

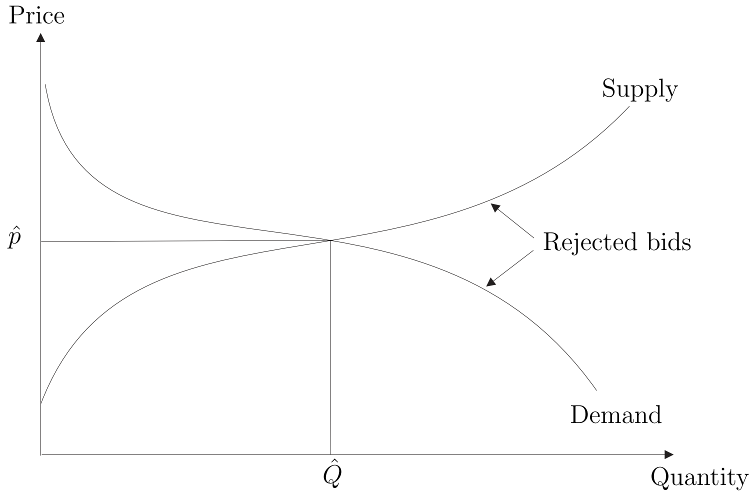
The producers can only give a *single bid* for buying and a *single ask* for selling at the Danish quota exchange. We refer to this as *the single bid restrictions.* The basic trading rules can be summarized as follow:

- A seller submits one ask, i.e. the quantity he wants to sell and the minimum price he requires.
- A buyer submits one bid, i.e. the quantity he wants to buy and the maximum price he is willing to pay.

Based on all bids a single clearing price is found and:

- Buyers with maximum prices above or equal to the clearing price buy their requested quantity at the clearing price.
- Sellers with minimum prices below or equal to the clearing price sell their offered quantity at the clearing price.

Figure 1: The Quota Exchange



- All other bids and asks are rejected.

The Danish dairy board runs the exchange (i.e. operates the clearing house). In order to always clear the exchange using the above rules, the Danish dairy board holds a small buffer of quota. This means that buyers bidding exactly the clearing price always buy their requested quantity, even if there is excess demand for quotas at the market clearing price. Similarly, sellers asking exactly the clearing price always sell their offered quantity.

The exchange is illustrated in Figure 1 where $\hat{p}$ clears the exchange and $\hat{Q}$ is redistributed on this exchange.

The Danish milk quota exchange can be characterized as a *single price sealed bid double auction*. I.e. producers submit sealed bids and asks and all trade is settled at a single price.

In addition to the single bid restriction buyers are subject to quantitative restrictions. Although the effects of the quantitative restrictions are interesting, we restrict our analysis to the single bid restrictions.

3 Single Bid Exchange

In a perfect market all wealth enhancing trades are realized. All producers with marginal valuation of quota below the market price sell quota, and all producers with marginal valuation of quota above the market price buy quota.

Restricting the producers to submit only a single sealed bid and a single sealed ask has two effects:

The aggregation effect: The single bid restriction limits the information transmitted through the exchange. A buyer cannot express a downwards sloping demand curve and a seller cannot express an upwards sloping supply curve.

The uncertainty effect: The uncertainty about the clearing price systematically affects the producers' bids and asks.

3.1 The Aggregation Effect

Let $Z_B(q)$ be the price a buyer bids and $Z_S(q)$ be the price a seller asks for the quantity q. We show in section 3.2 how $Z_B(q)$ and $Z_S(q)$ are determined. For now, we assume that $Z'_B(q) \leq 0$ and $Z'_S(q) \geq 0$, i.e. buyers have downward sloping bid functions and sellers have an upward sloping bid functions.

Due to the single bid restriction a producer must choose a single point on $Z_B(q)$ as his bid and a single point on $Z_S(q)$ as his ask.

Once a producer has observed the market clearing price, he may want to change his bid or ask.

- A buyer who bid above the clearing price (and had his bid accepted) may wish that his bid was submitted on a larger quantity.
- A buyer who bid below the clearing price (and had his bid rejected) may wish that his bid was submitted at a lower quantity – offering a higher price so that his bid would have been accepted.

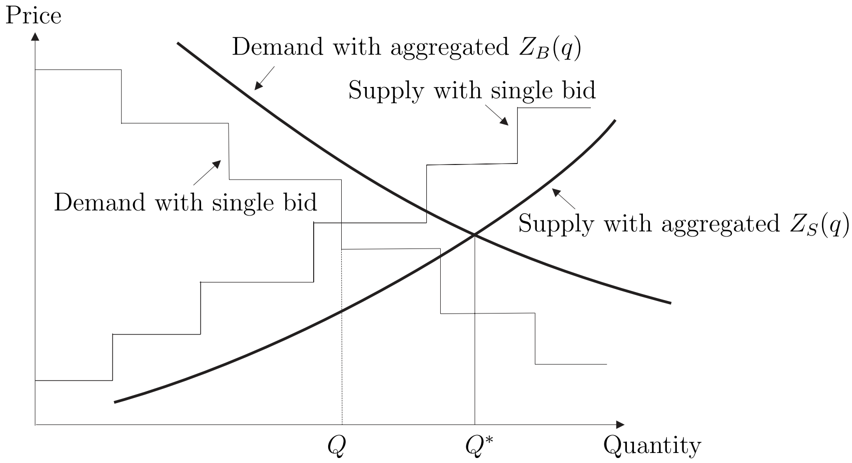
Hence, the demand curve revealed on the milk quota exchange is below the horizontal aggregation of the buyers' bid functions, $Z_B(q)$.

There are similar effects on the supply side:

- A seller who asked for a lower price than the clearing price (and had his ask accepted) may wish that his bid was submitted on a larger quantity.
- A seller who asked for a higher price than the clearing price (and had his ask rejected) may wish that his bid was submitted on a lower quantity (asking a lower price) so that his bid would have been accepted.

Hence, the supply curve revealed on the milk quota exchange is above the horizontal aggregation of the sellers bid functions, $Z_S(q)$. The aggregation effects are illustrated in Figure 2.

Figure 2: Single bid versus multiple bids auction



It is straightforward to see that the single bid restriction leads to less trade than a market clearing with the buyers' and sellers' horizontally aggregated bid functions. The reason is that a single bid does not transmit information about the quantity a buyer requests for prices above the bid price. Neither does a single bid transmit information about the additional quantity a buyer requests for prices below the bid price. Of course, the argument can be repeated on the sellers' side.

3.2 The Uncertainty Effect

In this section, we show how a rational producer chooses the bid and ask he submits on an exchange with a single bid restriction. That is, we determine a producer's bid functions $Z_B(q)$ and $Z_S(q)$, respectively. We also show which point on $Z_B(q)$ a buyer submits as his bid and on $Z_S(q)$ for a seller.

The uncertainty about the clearing price affects the producers' bid function. The producers try to minimize the risk of foregoing profitable trade. The producers can forego profitable trade either because their bid/ask is rejected or because they buy/sell too little on the exchange.

We make the following assumptions:

- the producers are price-takers, i.e. the individual producer cannot influence the clearing price.
- the producers are risk neutral, i.e. the individual producer maximize the expected value of his bid and ask.
- the producers have ex ante beliefs about the clearing price. These beliefs are described by a density function $f(\hat{p})$ where $\hat{p}$ is the clearing price. Our model does not require that all producers have the same beliefs, but to simplify the notation, we suppress the producer identity.
- the producers' valuation of quota are independent. This means that we do not consider the problem of winners curse[1] in our model.

In Section 6, we discuss the implications of our assumptions. We now model the milk quota exchange as a one-shot single price sealed bid double auction.

3.2.1 The Buyer's Problem

Consider a buyer with an inverse demand function $P_B(q)$. That is, $P_B(q)$ is the marginal value of quota when q units are acquired. If a bid of quantity q is accepted at a clearing price $\hat{p}$, the profit to the buyer is

[1]The winners curse is the tendency that the producers who end up buying milk quota at the quota exchange are those who overestimate the profitability of milk production.

$$\int_0^q (P_B(x) - \hat{p})\, dx \tag{3.1}$$

The bid is accepted as long as the bid price p exceeds the clearing price $\hat{p}$. The buyers expected value, $\pi_B(p,q)$, from bidding (p,q) is therefore

$$\pi_B(p,q) = \int_0^p \left(f(\hat{p}) \int_0^q (P_B(x) - \hat{p})\, dx \right) d\hat{p} \tag{3.2}$$

The first order condition for an optimal bid price p can now be expressed as:[2]

$$\begin{aligned}
\frac{\partial \pi_B}{\partial p} = f(p) \int_0^q (P_B(x) - p)\, dx = 0 \iff \\
\int_0^q P_B(x) dx = p \cdot q \iff \\
A_B(q) = p
\end{aligned} \tag{3.3}$$

where $A_B(q)$ is the average value, $\int_0^q P_B(x)dx/q$, of the quota q.

The first order condition for the quantity component q of the optimal bid is:

$$\begin{aligned}
\frac{\partial \pi_B}{\partial q} = \int_0^p f(\hat{p})\, (P_B(q) - \hat{p})\, d\hat{p} = 0 \iff \\
\frac{\int_0^p \hat{p} \cdot f(\hat{p}) d\hat{p}}{\int_0^p f(\hat{p}) d\hat{p}} = P_B(q) \iff \\
E(\hat{p}|\hat{p} \leq p) = P_B(q) \iff \\
D\left(E(\hat{p}|\hat{p} \leq p)\right) = q
\end{aligned} \tag{3.4}$$

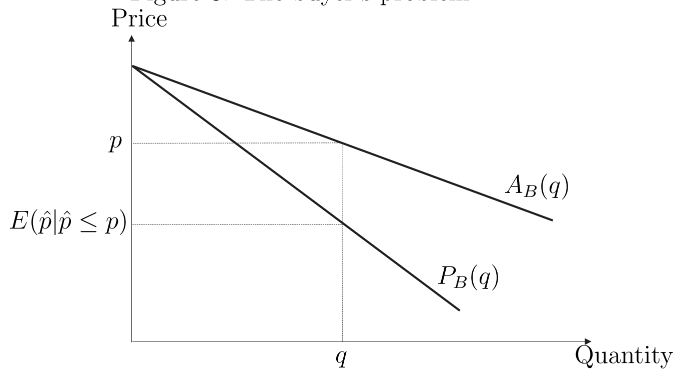
where $E(\hat{p}|\hat{p} \leq p))$ is the expected clearing price when the bid is accepted and $D(\cdot)$ is the demand function, i.e. $D(p) = P_B^{-1}(q)$.

A buyer must solve the two first order conditions (3.3) and (3.4) simultaneously. Figure 3 illustrates this.

The first order condition for the price (3.3) states that the buyers' price strategy is to bid the average value and not the marginal value of quota.

[2]Here and below assume that $\pi(\bullet)$ satisfy sufficient regularity conditions to ensure that the following rules apply: $\frac{\partial \int_a^b F(x,y)dx}{\partial y} = \int_a^b \frac{\partial F(x,y)}{\partial y} dx$, $\frac{d \int_a^b F(x,y)dx}{da} = -F(a)$, and $\frac{d \int_a^b F(x,y)dx}{db} = F(b)$, for the appropriate integrand F.

Figure 3: The buyer's problem



To understand this note that a producer wanting to buy quota risks ending up not buying at all on the quota exchange if his bid is too low. There is no benefit from bidding below the average value of a given quota, because the producers are price-takers and cannot affect the clearing price. On the other hand, the additional trade a producer can obtain by bidding a price above the average valuation of quota is unprofitable. Thus, the buyers deal with the uncertainty about the clearing price by bidding their average value of quota instead of their marginal value of quota.

We may summarize this in a proposition.

Proposition 3.1. *Consider a sealed bid single price exchange with a single bid restriction. A rational buyer uses his average value of quota as bid price:*

$$Z_B(q) = A_B(q) \tag{3.5}$$

and chooses the quantity, by inserting the expected price, conditional on the bid being accepted, into his demand function:

$$D\left(E(\hat{p}|\hat{p} \leq p)\right) = q \tag{3.6}$$

When the demand curve is downward sloping, the buyers price bid for a given quantity i.e. the average value of quota, is *higher* than the marginal value of quota $P_B(q)$. The uncertainty effect – therefore tends to increase the revealed demand.

3.2.2 The Seller's Problem

The solution to the seller's problem is symmetric to that of the buyer's problem. We use $P_S(q)$ as the inverse function of the seller's supply function.

If an ask of quantity q is accepted at clearing price $\hat{p}$, the profit to the seller is

$$\int_0^q (\hat{p} - P_S(x))\, dx \tag{3.7}$$

Using a bid price of p, his bid is accepted whenever $\hat{p} \geq p$, and his resulting expected profit is therefore:

$$\pi_S(p,q) = \int_p^\infty \left(f(\hat{p}) \int_0^q (\hat{p} - P_S(x))\, dx \right) d\hat{p} \tag{3.8}$$

The seller maximizes the expected profit.

The first order condition for an optimal ask price is:

$$\begin{aligned}
\frac{\partial \pi_S}{\partial p} = -f(p) \int_0^q (p - P_S(x))\, dx = 0 \iff \\
\int_0^q P_S(x)dx = p \cdot q \iff \\
A_S(q) = p
\end{aligned} \tag{3.9}$$

where $A_S(\cdot) = \int_0^q P_S(x)dx/q$ is the seller's average value of quota.

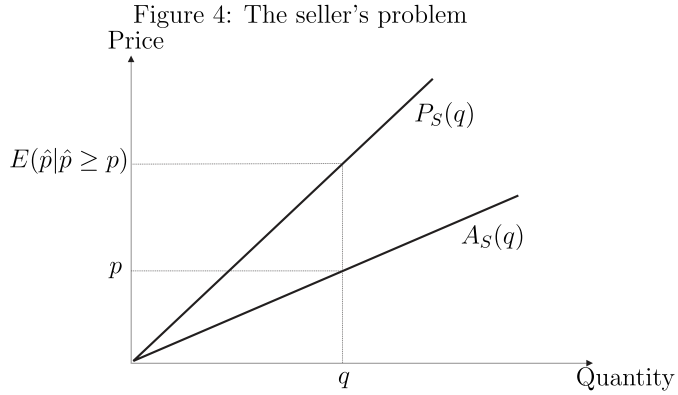
The first order condition for the quantity component of the bid is:

$$\begin{aligned}
\frac{\partial \pi_S}{\partial q} = \int_p^\infty f(\hat{p})\,(\hat{p} - P_S(q))\, d\hat{p} = 0 \iff \\
\frac{\int_p^\infty \hat{p} \cdot f(\hat{p})d\hat{p}}{\int_p^\infty f(\hat{p})d\hat{p}} = P_S(q) \iff \\
E(\hat{p}|\hat{p} \geq p) = P_S(q) \iff \\
S\left(E(\hat{p}|\hat{p} \geq p)\right) = q
\end{aligned} \tag{3.10}$$

where $E(\hat{p}|\hat{p} \geq p)$ is the expected price given that the ask is accepted and $S(\cdot)$ is the usual supply function $S = P_S^{-1}$.

The seller must solve the two first order conditions (3.10) and (3.9) simultaneously. This is illustrated in Figure 4 below.

Figure 4: The seller's problem



The first order condition for the price (3.9) shows that the seller's price strategy is to ask the average as opposed to the marginal value of quota. To understand this, observe that if he submit an ask price above his average value, he simply risk foregoing profitable trade. If he submits an ask below his average value, the additional trade this will generate (relative to asking the average value) is unprofitable, since he receives less for the quota than it is worth to him. Hence, it is optimal for the producer to use the average value of quota as his ask price.

We summarize the characteristics of the seller's solution in a proposition as well.

Proposition 3.2. *Consider a sealed bid single price exchange with a single bid restriction. A rational seller uses his average value of quota as ask price:*

$$Z_S(q) = A_S(q) \tag{3.11}$$

and chooses the quantity by inserting the expected price, conditional on the ask being accepted, into his supply function:

$$S\left(E(\hat{p}|\hat{p} \geq p)\right) = q \tag{3.12}$$

With an increasing supply curve, the seller's price demand for a given quantity of quota is below the marginal value of quota $P_S(q)$. The uncertainty effect therefore – as opposed to the aggregation problem – tend to increase the revealed supply.

3.3 Numerical example

We now give a simple example of the model presented above. We only illustrate the buyer's problem, since the buyer's and the seller's problems are symmetric. In the example, the producer's demand function is $P_B(q) = 1 - q$, and we assume that the producer's beliefs about the market clearing price is uniform distributed $\hat{p} \sim \text{Uni}[0;1]$.

Using an uniform distribution simplifies the analysis, since all possible market clearing prices are weighted equally, that is: $f(\hat{p}) = 1$ for all $\hat{p} \in [0,1]$. Using equation (3.2), the buyer's problem is given by:

$$\max_{p,q} \int_0^p \int_0^q ((1-x) - \hat{p})\, dx d\hat{p} \tag{3.13}$$

The two first order conditions yield:

$$\begin{aligned} 1 - q &= E(\hat{p}|\hat{p} \leq p) \iff \\ 1 - q &= \frac{\int_0^p \hat{p} d\hat{p}}{\int_0^p 1 d\hat{p}} = \frac{1}{2}p \iff \\ q &= 1 - \frac{1}{2}p \end{aligned} \tag{3.14}$$

and

$$\begin{aligned} \frac{\int_0^q (1-x)\, dx}{q} &= p \iff \\ 1 - \frac{1}{2}q &= p \end{aligned} \tag{3.15}$$

The solution to this system of equations is: $p = \frac{2}{3}$ and $q = \frac{2}{3}$.

To emphasize the uncertainty effect, consider variations in the producer's belief. Let $\hat{p} \sim \text{Uni}[\varepsilon; 1-\varepsilon]$ such that a large value of $\varepsilon \in [0, \frac{1}{2}[$ indicates that the buyer has good price projections. Now the density function, $f(\hat{p})$, is $\frac{1}{1-2\varepsilon}$, but the expected equilibrium price is unchanged. In our analysis we now have to use $\min\{p, 1-\varepsilon\}$ as the upper limit for our integrals. The two first order conditions yield:

$$1 - q = E(\hat{p}|\hat{p} \leq p) \iff$$

$$1-q=\frac{\int_{\varepsilon}^{\min\{p,1-\varepsilon\}}\hat{p}\frac{1}{1-2\varepsilon}d\hat{p}}{\int_{\varepsilon}^{\min\{p,1-\varepsilon\}}\frac{1}{1-2\varepsilon}d\hat{p}}=\frac{\min\{p,1-\varepsilon\}+\varepsilon}{2}\iff$$

$$1-q=\frac{\min\{p+\varepsilon,1\}}{2} \tag{3.16}$$

and

$$\frac{\int_0^q(1-x)\,dx}{q}=p\iff$$

$$1-\frac{1}{2}q=p \tag{3.17}$$

Solving for p and q we get the optimal bid as: $p=\min\{\frac{2+\varepsilon}{3},\frac{3}{4}\}$, $q=\max\{\frac{2-2\varepsilon}{3},\frac{1}{2}\}$.

Hence, with a smaller uncertainty the buyer bids a higher price and a smaller amount. In the limit ($\varepsilon\to\frac{1}{2}$) there is no uncertainty. The buyer demands $q=\frac{1}{2}$ and offers $p=\frac{3}{4}$. In fact this property holds for all $\varepsilon\geq\frac{1}{4}$ ($E(\hat{p}|\hat{p}\geq p)=E(\hat{p})$, if $p\geq 1-\epsilon$). Since he does not influence the equilibrium price by his bid any bid above $p=\frac{1}{2}$ is accepted and he might as well submit his average valuation.

4 Multiple Bids Exchange

The analysis in Section 3 illustrates that the single bid restriction creates distortions (the aggregation effect and the uncertainty effect). In this section we show that allowing for multiple bids removes these distortions.

In D. Nautz (1995): "Optimal bidding in multi-unit auctions with many bidders" a similar situation is analyzed. Nautz analyze a discrete auction where the seller (mechanism designer) sets a grid of prices $p_0<p_1<\ldots<p_{k+1}$. The seller invites bidders to submit their bids in the form of demand schedules: $B(p_0)\geq B(p_1)\geq\ldots\geq B(p_{k+1})$. $B_i=B(p_i)$ states how many units the bidder is willing to buy at p_i. That is, the bidders can submit multiple bids. Nautz proves that the optimal strategy for the bidders is to bid their true demand function, i.e. $B(p)=D(p)$.

We shall now generalize Nautz's result to a continuous[3] auction where both buyers and sellers can submit multiple bids. We assume that the pro-

[3]That is, the clearing price can take a continuum of values.

ducers are price-takers and risk neutral and that the producers' private valuations of quota are independent. The inverse bid functions $B_B(\hat{p})$ and $B_S(\hat{p})$ on the clearing price, $\hat{p}$, state how large a quota the producer wants to buy/sell at price $\hat{p}$[4].

A buyer chooses the inverse bid function which maximizes his expected value of trading on the auction. The expected value of trading on the auction is the value of buying/selling the quantity $B(\hat{p})$ at the price $\hat{p}$ weighted by the probability of $\hat{p}$ being the clearing price. In order to maximize the expected value of trading on the auction, the producers must maximize the value of trading for each value of $\hat{p}$. This is done by bidding the demand function. The reason is that the demand function states the quantity which maximizes the value of trading at a given price. Hence, when the buyers can submit multiple bids it is optimal for them to submit their demand functions. The intuition on the sellers side is similar.

Proposition 4.1. *In a continuous single price sealed bid auction, the true demand and supply functions are the optimal inverse bid function:*

$$B_B(p) = D(p) \quad \textit{and} \quad B_S(p) = S(p) \tag{4.1}$$

Proof. A buyer maximizes the expected value of trading on the auction by solving the following problem:

$$\max_{B_B(\cdot)} \pi_B(B_B(\hat{p})) = \max_{B_B(\cdot)} \int_0^\infty \left(f(\hat{p}) \int_0^{B_B(\hat{p})} (P_B(x) - \hat{p})\, dx \right) d\hat{p} \tag{4.2}$$

where $B_B(\hat{p})$ is the inverse bid function which defines the quantity the producer wants to buy for each $\hat{p}$, $\hat{p}$ is the clearing price, $f(\hat{p})$ is the density function of $\hat{p}$ and $P_B(x) = D^{-1}(x)$ is the inverse demand function.

For all $\hat{p}$ the Euler's condition for the problem is:

$$f(\hat{p})\,(P_B(B_B(\hat{p})) - \hat{p}) = 0 \tag{4.3}$$

Solving for $B_B(\hat{p})$ yield:

[4]Note that $B(\hat{p})$ is the inverse of the bid function $Z_B(q)$ (used in Section 3.1), which express the price a producer bids for the quantity q.

$$B_B(\hat{p}) = P_B^{-1}(\hat{p}) = D(\hat{p}) \tag{4.4}$$

The argument runs similarly on the supply side. □

Proposition 4.1 emphasize that a multi bid auction is a truth revealing mechanism which leads to efficient trade.

5 Empirical analysis

In Sections 3 and 4 we showed that the single bid restriction leads to inefficiency. The size of the efficiency loss depends on the producers beliefs about the clearing price and on their supply and demand functions. In this section we estimate the efficiency loss in an empirical application.

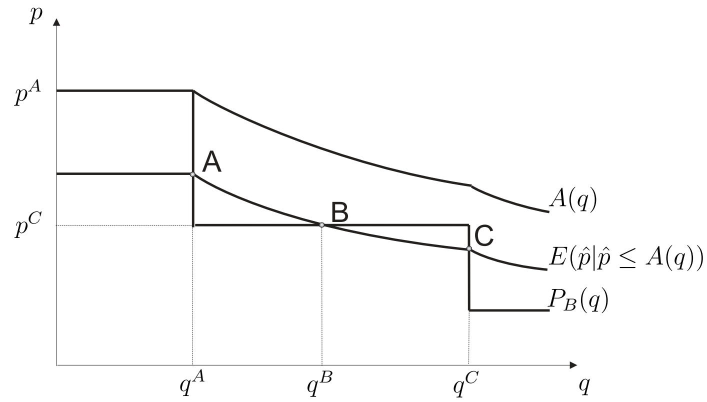
In the Danish milk quota exchange, bids and asks reflect price expectations as well as average values. One therefore needs panel-data combined with good expectations models to determine marginal values and hereby the likely behaviour in a multiple bid exchange. We do not have the necessary data therefore we cannot directly determine the expected gain from introducing multiple bids in Denmark

Several Canadian milk quota exchanges use multiple bids. Moreover the association: "Dairy Farmers of Ontario" have provided data from 11 auctions held monthly from September 1997. All producers in Ontario are allowed to buy and sell quota. There are no quantitative restrictions on the bids nor asks. The data set contains the individual bids and asks submitted on these 11 auctions[5]. On an average auction 488 buyers and 194 sellers participated. 20,3% of the buyers submitted more than one bid, and 12,2% of the sellers submitted more than one ask. We can use these data to evaluate the impact of introducing a single bid restriction.

In Section 4 we have shown that the optimal bidding strategy in a multiple bid auction is to submit the demand (supply) curve. The producers do not submit continuous demand and supply functions in practice but can provide an arbitrarily fine approximation using discrete points. Therefore,

[5]The first 7 auctions have been used of farmers from Quebec also, but the data set contains only the bids/asks submitted in Ontario. Although the first 7 clearing prices (calculated on the data set) differ from the official clearing prices, we use all 11 auctions.

Figure 5: The buyer's optimal single bid



we assume that the bids submitted on the Ontario milk quota exchange reveal the producers' true marginal value of quota.

Combining the assumed behaviour with the empirically few bids suggest that the producers marginal cost of producing milk is a step function. The nature of the production can explain this. Unless a producer has free capacity, expansion of production requires investments. On the other hand, if a producer has free capacity an expansion does not affect the marginal cost. Hence changing the capacity will change the marginal cost to another constant level. This explains the shape of the demand for milk quota as illustrated in Figure 5. Direct cost models of Danish milk producers show similar characteristics[6].

We assume that the producers have the same beliefs about the future clearing prices, and that the beliefs can be modelled as a normal distribution estimated upon the 11 official clearing prices from the auctions. The distribution of the clearing price, measured in CAD/kg butterfat/day is given by $N(15484, 702)$.

In Section 3 we proved that the producers will bid their average value, $A(q)$, and choose the quantity q such that $q = D(E(\hat{p}|\hat{p} \leq A(q)))$ or equivalent $P_B(q) = E(\hat{p}|\hat{p} \leq A(q))$. Figure 5 illustrates the situation for a buyer. The figure shows the step formed marginal values $P_B(q)$, derived from bids saying that a maximum of q^A will be bought at price p^A and that further

[6]Nielsen (1998) show that the marginal cost of producing milk is a step function.

units up to q^C will be bought at price p^C. Figure 5 also show the average values $A(q)$ and the truncated expected price $E(\hat{p}|\hat{p} \leq A(q))$.

We shall now determine how a farmer as depicted in Figure 5 would react in a single bid auction. The optimality condition from section 3 says that quantity q is set such that $P_B(q) = E(\hat{p}|\hat{p} \leq A(q))$. By the discrete nature of the problem this can happen for several levels of q. The optimal point is the one that yields the largest expected surplus to the buyer. In the figure we have 3 productions levels to consider: q^A, q^B and q^C. Bidding (q^A, p^A) gives, for example, an expected surplus of:

$$\text{Prob}(\hat{p} < p^A) \cdot (p^A - E(\hat{p}|\hat{p} \leq A(q)) \cdot q^A \tag{5.1}$$

where $\text{Prob}(\hat{p} < p^A)$ is the probability that the bid is accepted. After selecting the best single bids and asks we solve the clearinghouse. This gives us the equilibrium that would prevail if the producers were restricted to submit a single bid only. Comparing the equilibrium simulated under the single bid restriction to the equilibrium on the Ontario milk quota exchange enables us to compute the efficiency loss generated by the single bid restriction. The efficiency loss is the difference between the actual surplus in the two situations. For each buyer this can be calculated as follows:

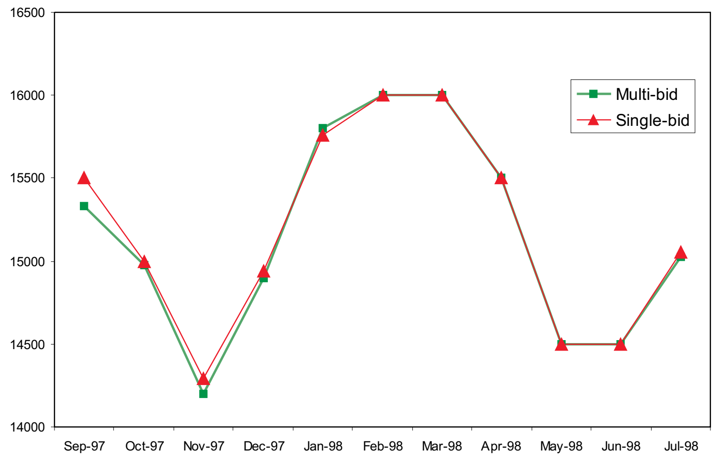
$$\begin{gathered}\text{Surplus multiple bids} - \text{Surplus single bid}\\ \sum_{j=1}^{M} \max\{(p_j - \hat{p}_{\text{multi}}), 0\}\Delta q_j - \max\{(p - \hat{p}_{\text{single}}), 0\}q\end{gathered} \tag{5.2}$$

where j indexes the multiple bids, Δq_j is the additional quantity demanded at p_j compared to p_{j-1}, and p, q is the buyer's optimal single bid.

Figure 6 shows the resulting clearing prices in the two setups, single and multiple bids/asks. The figure shows that the clearing prices under the single bid restriction lies close to the clearing prices under the multiple bids setup. This justifies the use of the same expectations about the clearing price in both situations. Moreover the model is robust to changes in the uncertainty; for instant doubling the variance hardly change our results.

Table 1 show the results for the 11 auctions, all numbers are in million CAD. The table show for each auction the surplus when allowing for multiple bids and under the single bid restriction. The net loss is the efficiency loss from introducing a single bid restriction. The last two columns show the

Figure 6: The market clearing prices



efficiency loss in percentages of total surplus and total turnover generated on the Ontario milk quota exchange.

On average the single bid restriction would reduce the total surplus on the Ontario milk quota exchange by 2.5 percent. Of course several facts can contribute to this some what limited difference.

Very important is the stepwise marginal cost curve in milk production. It makes it possible to approximate the marginal values in the relevant region using only a single or a few bids. Since the Ontario exchange are repeated frequently, possible miss allocation can be corrected without too long delay. A detailed picture of the cost condition may therefore not be submitted in each auction. This suggest that the cost curve we enter may be too simple, which in turn makes us underestimate the loss from a single bid restriction.

Both the Danish and the Ontario quota exchanges are repeated at fixed intervals. The producers can improve an inefficient allocation in the next exchange. This potential makes the inefficiencies of a temporary nature.

Table 1: Losses from single bid restrictions (in million CAD)

	Total surplus			Net loss of total:	
	Multiple	Single	Net loss	Surplus	Turnover
September 1997	2.35	2.19	0.017	7.6 %	1.19 %
October 1997	1.54	1.50	0.051	3.4 %	0.43 %
November 1997	2.88	2.86	0.019	0.7 %	0.13 %
December 1997	2.23	2.21	0.023	1.0 %	0.16 %
January 1998	1.43	1.39	0.039	2.9 %	0.26 %
February 1998	1.94	1.86	0.078	4.2 %	0.40 %
March 1998	1.67	1.64	0.029	1.8 %	0.15 %
April 1998	1.43	1.40	0.028	2.0 %	0.21 %
May 1998	4.02	3.99	0.029	0.7 %	0.15 %
June 1998	3.89	3.79	0.096	2.5 %	0.46 %
July 1998	1.99	1.93	0.065	3.4 %	0.56 %
Average	2.31	2.25	0.057	2.5 %	0.36 %

6 Discussion

In this paper we have assumed that the producers are price takers. This rules out strategic behavior. The assumption is justified by the high number of participants in the exchanges[7]. Moreover, as mentioned in the introduction, strategic behavior in double auctions does not seem important in empirical studies and laboratory experiments with even a low number of participants.

Another simplification is the assumption that the producers are risk neutral. Under the single bid restriction, introducing risk aversion make the buyer reduce the risk by bidding a lower quantity at a higher price. In a multiple bids setup, risk aversion will not change the optimal bidding strategy. The reason is that a producer cannot influence the clearing price, so the best he can do is to reveal his true marginal values. This is well known from the literature on second price auctions (Klemperer 1999). Hence, introducing risk aversion will not change the main conclusion that allowing for multiple bids is the optimal rule.

A third assumption is that of independent private values of milk quota.

[7]On the Danish exchange from 1997 to 2000 there were approximately 5000 bids and asks per exchange.

The private values come mainly from the individual producers cost of producing milk. In reality there are common elements that can make the valuations dependent on each other, e.g. resale value, the political agenda, interest rate etc. These common effects are left out of the model.

Our analysis is static. This is important for two reasons. First a dynamic free market is difficult to approximate by a discrete set of exchanges unless the preferences are relatively stable between the exchanges. Second, if the producers have stable preferences two single bid exchanges resembles one exchange with a two bid restriction. With two or more bids both the aggregation and the uncertainty effects are reduced.

We use the static model to evaluate the impact of imposing a single bid restriction on the Ontario milk quota exchange. Most of the producers only submit one bid at each exchange. One reason for this might be that a producer can submit a new bid the following month if his bid is rejected. This reduces the impact of a single bid restriction. On the Danish quota exchange a producer has to wait for 6 months before he can submit a new bid. This makes each Danish quota exchange more similar to a one shot event than the Ontario exchange. Thus the single bid restriction probably has more impact on the efficiency of the Danish milk quota exchange than on the efficiency of the Ontario milk quota exchange.

The quantitative restrictions on the Danish exchange might reduce the inefficiency generated by the single bid restriction. This is so because the producers need less bids to express their now truncated demand. On the other hand the quantitative restrictions introduce inefficiencies of its own by restriction the trade-volume between producers with very different values. Limiting the trade introduce a new sort of inefficiency, which is not included in our model.

We have assumed all producers to be rational with sufficient analytical capacities to deduce optimal bidding strategies etc. In reality, producers may only be bounded rational. In discussing our approach with the Danish Dairy Board it has been suggested that the producers are only bounded rational. The producers find it very complicated to submit bids on the exchange. If they were to submit multiple bids the industry expect that they might get more confused. Still, we suggest that it is easier for a producer to submit multiple bids than a single bid. In order to submit multiple bids, the producer must know his marginal values, i.e. demand function $D(p)$ and supply function $S(p)$. To submit a single bid, the producer must deduce his strategy and figure out which point to submit. This requires that he forms beliefs about the clearing price (i.e. $f(\hat{p})$). Hence, if the single bid restriction is removed a producer may have to submit more bids—but it is easier to figure out which bids to submit.

7 Conclusion

This paper has shown that the single bid restriction on the Danish milk quota exchange leads to inefficient trade. There are two effects: The aggregation effect and the uncertainty effect.

A multiple bid exchange will eliminate these inefficiencies. In other words, allowing for multiple bids will generate efficient trade. Moreover it is easier to deduce the optimal multiple bid strategy than the optimal single bid strategy.

We have also evaluated the inefficiency in an empirical context. We estimated the efficiency loss from introducing a single bid restriction on the Ontario milk quota exchange. The analysis showed that on average an efficiency loss of 2.5% of the total surplus can be expected. The somewhat limited loss in practice is due to the stepwise marginal cost curve in milk production.

In this paper we have not combined the aggregation effect and the uncertainty effect in a unified equilibrium model. As other research in double auctions has shown, the analytical work required tend to get very complex. This however is an interesting issue for further research.

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Part 5.

Design of Production Contracts: Lessons from Theory and Danish Agriculture

By
Peter Bogetoft
and
Henrik Ballebye Olesen

Preface

The organization of agriculture is changing. Fewer and fewer products are traded on open markets and production contracts are more and more common. The increased vertical coordination, often referred to as the industrialization of agriculture, raises a number of new problems. In this book we address some of the micro economic issues related to this development.

This book concludes the project *"Economic Analysis of Danish Agricultural Contracts"*. The aim of the project has been to combine the theory of contracts with the practice of contracts. We have tried to understand (and in some cases improve) existing contracts by using modern contract theory, and in particular transaction cost theory and principal-agent theory. At the same time, we have tried to synthesize the contracting practice in different sectors of Danish agriculture to facilitate the dissemination of information and learning from best practice.

The project has required close contacts with practitioners in the food industry. We would like to thank companies and organizations for their willingness to provide information on their contracting practice. We are also grateful for their interest in the project and for their rather open-minded discussions of "their" contracts.

We would also like to thank participants at several seminars and in particular the participants at the International Workshop on Contracts in Danish Agriculture we organized in year 2000.

We have benefited from financial support of *Norma og Frode Jacobsen Fonden* (Norma and Frode Jacobsen's Trust). The aim of the Trust is to support research that promotes the competitiveness of Danish agriculture, in particular the pig industry. The support of *Norma og Frode Jacobsen Fonden* has made it possible to organize the workshop and to employ three research assistants. The research assistants, Henriette Broman, Pia Sebelin Skogø and Frederik Rygaard Svare, have been responsible for much of the contact with the food industry, and we greatly appreciate the work they have done.

Finally, Peter Bogetoft would like to thank his family, Victoria, Rasmus, Stina and Nete for their support on yet another big project. Henrik B. Olesen would like to thank Pia for her help and encouragement throughout this work.

Copenhagen, December 2001

Peter Bogetoft *Henrik Ballebye Olesen*

Content

CHAPTER 1.

Introduction

Too often, contracting theorists and contracting practitioners live separate lives. The theorists put forward advanced solutions to over-simplified and stylized problems. The practitioners develop ad hoc solutions to complicated realities.

In this book, we allow theory and practice to interact. We try to understand (and in some cases improve) existing contracts by using modern contract theory, and in particular transaction cost theory and principal-agent theory. At the same time, we try to synthesize the contracting practice in different sectors of Danish agriculture to facilitate the dissemination of information and learning from best practice.

We firmly believe that both theorists and practitioners can benefit from this interaction.

Practitioners often rely on a trial-and-error process where contracts are gradually improved as the limitations of current solutions show up. The difference between old contracts, e.g. the rather advanced contracts on peas, and new contracts illustrates the evolution of contracting practice. However, the disadvantage of the trial-and-error approach is that the lessons from such experiments are expensive and to some extent random and sporadic. Learning from the ideas of theorists is generally cheaper and it is relatively easy to perform controlled and systematic experiments at the desk. Therefore, practitioners can benefit from interaction with theorists and, of course, from a systematic summary of contracting practice.

On the other hand, theorists often use grossly over-simplified models. This improves our understanding of the fundamental forces in contracting, but tends to make us forget that the different forces work in combination. Also, theorists can easily lose sight of the empirical significance of alternative forces and without such a perspective anything may seem relevant. The practice of contracting challenges the theorists to come up with new results. In particular, we suggest that more work is required on how to analyze several forces simultaneously and more specifically how to combine aspects of coordination and motivation.

1.1 The Theory of Contracting

In recent decades there have been rapid developments in contract theory. The emphasis on incentive and informational asymmetries has had a significant impact on microeconomics. While retaining the simplicity of the neoclassical approach, the introduction of information and incentives has greatly extended economic disciplines and provided explanations for previous irrationalities.

The rapid development of contract theory has relied on stylized models, where the effects are relatively easy to trace analytically. Hence, based on the principle of abstraction, contract theory has generated a number of valuable lessons.

The economic theory of contracts has had contributions from several areas, of which agency theory and transaction cost theory are the most important. They overlap each other as agency theory gives an in depth analysis of a subset of the broader issues which are addressed with less precision in transaction cost theory.

Agency theory[1] is concerned with the design of incentive schemes when one person (the agent) acts on behalf of another person (the principal). The provision of incentives is complicated by asymmetric information, i.e. information which only one of the contracting parties has access to. The theory distinguishes between information asymmetry before contracting (adverse selection) and after contracting (moral hazard). There is extensive literature on optimal incentive schemes under different circumstances, e.g. different informational structures, repeated relationships, multiple agents, agents performing a multiplicity of tasks etc.

The costs of making and administering a contract are largely ignored in agency theory. *Transaction cost theory*[2] is concerned with such contracting costs. Transaction costs lead to incomplete contracts which do not specify all possible contingencies. Transaction cost theory explains the existence of different contracts by means of a broad range of variables, including the institutional framework, bounded rationality and uncertainty.

A common criticism of transaction cost theory is that it is so broad and loose that it *explains everything*. In effect, it explains nothing because the predictive power of the theory is too low. A similar criticism can also be raised made agency theory. Although we agree with this criticism to some extent, we do not find the theories useless. They offer a perspective and a set of concepts that allow us a much better understanding of the complex problems of contracting.

Despite recent advances in contract theory, we believe that they are still *insufficient* and that attempts to apply them in practice reveal several aspects that require further development. The theories stress motivation and develop advanced tools to cope with dishonesty (cheating and lying). Unfortunately, coordination for ensuring that the right people are doing the right things at the right time and place are largely ignored. In practice, coordination is just as important and a more balanced theory offering a combination of motivations and coordination tools would be much more valuable. Also, the theories typically work with very simple one-input, one-output production models which make unrealistic assumptions about the underlying technology[3]. It would be beneficial to introduce more complex multi-dimensional

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[1] Cf. Bogetoft (1994) and Salanié (1997).
[2] See Williamson (1996).
[3] This criticism has also been made by Chambers and Quiggen (2000).

production models and to investigate the interaction between the complexities of technology and motivational problems.

1.2 The Practice of Contracting

Contracts have played an important role in Danish agriculture for many years. This suggests that firms and farmers have acquired valuable knowledge about the design and management of contracts. This book summarizes some of this knowledge.

In working with the specific contracts, we have learned many things that have implications for theory.

Firstly, actual contracts can be just as advanced as recent progress in the contract theory. From this perspective, the primary role of research is to understand and rationalize existing practice.

Secondly, there are considerable variations in the ingenuity of the contracts. In particular, it seems that contracts undergo numerous improvements over time. New contracts are often rather naive and do not take account of some very important problems.

Thirdly, practitioners often design contracts without using contract theory. Instead, the design of a contract is often based on experience and a process of trial-and-error. This has advantages, but it is often an unsystematic, costly and uncertain approach that can be improved by just a little more interaction with theory.

Based on these observations, we conclude that a theory-based approach to reality and systematic dissemination of information between different agricultural sectors can be a valuable supplement to the existing practice.

1.3 Combining Theory and Practice

Papers in contract theory typically focus on just one or at most a few problems. This is natural from a scientific point of view, because theoretical innovations often require the use of stylized models where it is possible to trace the effects analytically. However, as a means of practical guidance, such a partial approach is not satisfactory. The risk is that while solving one issue in a contractual relationship, new problems may be created. Another risk is that the analysis will focus on minor problems and ignore more important problems in the contract. In practice, it is necessary to consider all aspects of a contract simultaneously. This calls for a holistic approach to contract theory.

In this book we use the conceptual framework of *multi-criteria decision-making.* We consider the design of a contract as a decision-making problem. In particular we have developed a checklist of ten rules of thumb in contract design (Chapter 2) and a goal hierarchy of the problems a contract must address (Chapter 3).

The checklist and the goal hierarchy are centered around three *main problems* in contract design:

- coordination: ensuring that the right products are produced at the right time and place
- motivation: ensuring that the contracting parties have individual incentives to take socially desirable decisions, and
- transaction costs: ensuring that coordination and motivation are provided at the lowest possible cost.

The *context* is very important in contract design. It determines the relative importance of the different problems identified in contract theory. For instance, coordination may be the most important factor in one relationship while motivation may be the most important issue in another. The same contract can have very different consequences in sectors with different production technologies. Therefore, we use information about the production technology, the market structure and the ownership structures when analyzing specific contracts.

Our approach can be characterized as a mixture of positive (descriptive) and normative (prescriptive) approaches.

We use a *positive approach* when we describe the contracts and try to explain why we observe them. We take the positive approach for several reasons. Firstly, actual contracts often involve clever solutions to different problems. Such solutions may inspire practical contract design and contribute to the development of contract theory. Secondly, the context is very important in contract analysis so it is necessary to understand the context before the contract can be analyzed. Thirdly, it is easier to implement a contract by using well-known mechanisms. For example, if the producers have previously worked with quotas, a processor can introduce production rights without needing to educate the producers in optimization under quota constraints. Therefore it is quite common for actual contracts use elements from other well-known contracts or instruments known from the agricultural policy.

We also use a *normative approach* and ask the question: how should the contract be designed? Three arguments justify this approach. Firstly, actual contracts tend to improve over time. This suggests that a number of the contracts observed have not yet reached their optimal form. Contract theory may help the practitioners to improve such contracts. Secondly, our systematization of contract theory and the experience of contracts in practice can be used in cases where the practitioners do not have experience either because they want to introduce a new contract or because the context has changed. Thirdly, we believe that our framework can be used to anticipate problems in contractual relations. We realize, of course, that researchers must be cautions when giving such normative recommendations as they may not fully grasp all details of a given context.

The *agricultural sector* is a well-suited for attempts to combine the theory and practice of contracting. Agricultural production has many characteristics which make coordination and motivation mechanisms necessary.

Traditionally, the agricultural sector has had many small farmers trading with a few large processors. Often the farmers must make considerable investments. This means that farmers are tied in by their investments putting them in a vulnerable position. The processor can exploit this vulnerability to improve his trading terms. To avoid the under-investment resulting from such hold-up threats, some vertical integration is needed.

Recent trends in consumer demand have amplified the need for vertical integration. Many of the product qualities that are now in demand must originate at the farm level and must be documented throughout the production chain. This increases the need for coordination and motivation.

One way to improve coordination is via vertical integration. If the processor owns the farms he can ensure coordination. However, such centralized decision-making may generate moral hazard problems if the processor cannot detect whether the employees on the farm act as planned. This is a difficult task given the relatively low programmability of farming due to biological uncertainty. Centralized decision-making may also mean that relevant local information is not included in the decision-making.

Another way to tackle coordination and motivation problems is via producer-owned cooperative processors. Cooperatives are widespread in the agricultural sector. They represent an interesting intermediate form between independent farmers and vertically integrated farmers.

A third coordination and motivation device is production contracts. By regulating trading terms prior to investment, many hold-up problems can be eliminated. And by paying rewards for the desired product characteristics, the supply and demand sides can be coordinated. We emphasize that contract production is not necessarily an alternative to cooperatives or to fully integrated producer-processor organizations. Contracts can be useful, and are widely used by investor-owned and cooperatively owned organizations as a supplement to other motivation and coordination mechanisms.

1.4 The Research Project

This book is based on the research project *"Economic Analysis of Danish Agricultural Contracts"* sponsored in part by the Norma and Frode S Jacobsen Trust. This project has required a close dialogue with practitioners. The interaction between contract theory and the practice of contracting is only possible through discussions between the two worlds. Therefore this research project has involved considerable amounts of fieldwork. The research project has consisted of four phases.

The *first phase* was to collect a broad range of contracts used in Danish agricultural sectors. In this phase we also collected background information on the production and market conditions.

In the *second phase* we made initial analysis of the contracts. We developed a theoretical framework for contract analysis based on the concepts of coordination, motivation and transaction costs. To understand the possible rationales of the contracts, we interviewed representatives of the processors and the producers.

The *third phase* was a *workshop* on contract in Danish agriculture. We invited two groups of participants – international experts on contract theory and practitioners from the Danish food industry. During a two days event, we analyzed selected contracts between farmers and the food industry using the diverse insights of the participants.

The practitioners from the Danish food industry at the workshop were: Mogens Christensen, Vallø Saft A/S, Henning Otte Hansen, Klaus Sørensen and Karl Christian Møller, Danish Agricultural Council, Christian Stigaard Sørensen, Danisco Foods A/S and Martin Martin, Danish Crown.

The researchers attending the workshop were: Per Agrell, Peter Max Friis Jensen, Angelo Zago and Kostas Karantininis, The Veterinary and Royal Agricultural University, Denmark, John Christensen, SDU-Odense University, Pierre Dubois, ESR Toulouse, Jesper Graversen, Danish Institute of Agricultural and Fisheries Economics, Brent Hueth, Iowa State University, Tomislav Vukina, North Carolina State University.

In the *fourth phase* we have compiled this book. The work has been inspired by the fruitful discussions at the workshop and completed in close dialogue with practitioners from the Danish food industry. In particular, the companies involved have all approved the descriptions of the industries and contracts that we provide in the fact sheets (chapter 6).

1.5 Readers Guide

The book is aimed at three groups of readers.

Business people and *decision-makers* can use the analytical framework of the book to evaluate production contracts.

Students can use the book as an introduction to applied contract theory. The book also provides a catalog of problems relevant for papers on contract theory.

Researchers can be challenged to make new use of and new contributions to contract theory. The work on this project has generated a number of research ideas that we are presently exploiting in other more theoretical papers.

The book has been written so as to be accessible to readers who are not familiar with the often mathematically oriented theories of contracting. We keep the mathematical notation in the text at a minimum and in most of the chapters the general text is without math. We provide more explicit formulations in mathematical footnotes and appendices.

The remainder of this book consists of five chapters.

Chapter 2 distils the main lessons of this research project and presents them as ten rules of thumb. We also give numerous examples of how these rules apply to the Danish agricultural contracts. The resulting guidelines thus offer a systematic, practice-oriented review of contract theory. Practitioners can use the rules of thumb as a practical checklist for contract design.

Chapter 3 gives a non-technical overview of contract theory. The basic idea in the chapter is to develop a holistic framework for the analysis of contracts. The different aspects of contract theory are arranged in a goal hierarchy, which can be used by practitioners and theorists alike as a guideline for contract design. The goal hierarchy is developed around the three main aspects of contract theory: coordination, motivation and transaction costs. The goal hierarchy addresses both short and long-term problems in contractual relationships.

Chapter 4 gives an in-depth analysis of the Danisco Food contract for production of peas for consumption. Production of peas requires a highly accurate coordination, which is achieved through centralized decision-making. The contract is based on a tournament system. General problems in contract theory such as hold-up, moral hazard, risk sharing and discrimination are analyzed. By negotiating the contract through The Pea Growers Association, the farmers gain some bargaining power. Thus the farmers can ensure that Danisco Foods only uses one contract for all farmers. The consequences of the farmers' strategy also analyzed.

Chapter 5 analyzes the contracts used by the cooperative, Danish Crown, for production of special pigs. The standard pig producers are a majority in the cooperative. They can therefore control the cooperative to maximize their own profit rather than the integrated profit. The special pig producers are paid according to two different bonus systems. The market-determined bonus system let the bonus for producing special pigs increase in proportion to the quantity of the special pigs that are actually processed as special pigs (rather than as standard pigs). In the fixed bonus system, the bonus does not depend on the extent to which the pigs are actually used as special pigs. We analyze the consequences of choosing one or the other bonus system.

Chapter 6 describes eight production contracts in Danish agriculture. The production and market conditions, the ownership structure, and the most important elements of these contracts are described in fact sheets. The fact sheets are made in cooperation with the contract parties and have been approved by the contract parties, i.e. the firms and producer organizations. The facts sheets offer a systematic survey of how actual contracts address different specific problems. We believe this catalogue can be useful for practitioners as well as researchers.

CHAPTER 2.

Ten Rules of Thumb in Contract Design: Lessons from Danish Agriculture

Abstract

Real contracts must balance a number of conflicting objectives taking into account a number of different aspects of the contracting situation. Contract theory provides useful insights but the formal models used in the theory tend to focus on a few effects in stylized environments. The risk of a partial approach is that while improving one aspect of a contract, new and more serious problems may arise in other aspects. Practical contract design can therefore benefit from a more systemic approach ensuring that all relevant aspects are considered. In this paper, we offer a checklist that can support such a holistic approach to contract design. The checklist is based on experiences from Danish agricultural contracts. It covers the issues from contract theory that we have found to have particular relevance when understanding and improving real contracts. The checklist gives ten rules of thumb covering the basic issues of coordination, motivation, and transaction costs.

2.1 Introduction

Contract design is a complex task. Contract theory identifies numerous issues of potential importance. Typically, however, individual papers in contract theory focus on just one or a few problems. This is natural from a scientific point of view but as a means of practical guidance, such a partial approach is not satisfactory. The risk is that while solving one issue in a contractual relationship, one may end up creating new problems. In practice, it is necessary to consider all aspects of a contract simultaneously.

Contracts have played an important role in Danish agriculture for many years. This suggests that firms and farmers have acquired valuable knowledge about the design and management of contracts. We have tried to extract and synthesize some of this knowledge in a research project[1]. This paper summarizes a number of our findings in a rule-of-thumb format.

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[1] The Norma and Frode S Jacobsen Trust supported the research project *"Economic Analysis of Contracts in Danish Agriculture"*.

The research project has focused on contracts between producers and processors. We have collected a broad spectrum of the contracts used in Danish agriculture as well as information about the specific characteristics of the different sectors. To understand the possible rationales of the contracts, we have interviewed representatives of the processors and the producers. Also, we have developed a theoretical framework for contract analysis based on the concepts of coordination, motivation and transaction costs. We have used the theoretical framework to analyze the contracts with the aim of understanding and if possible improving specific contracts. This work has been documented in papers with detailed analysis of specific contracts[2] and a number of fact sheets providing basic information and analytical observations about all the contracts[3].

We have found that actual contracts can be just as advanced as recent progress in the contract theory. From this perspective, the primary role of research is to understand and rationalize existing practice. On the other hand, we have also found considerable variations of ingenuity in contracts. In particular, it seems that contracts undergo numerous improvements over time. This suggests that a systematic, theory-based approach and information dissemination between different agricultural sectors can be valuable.

In this paper, we distil the main lessons of this research project and present them as ten rules of thumb. We also give numerous examples of how these rules apply to Danish agricultural contracts. The resulting guidelines hereby offer a systematic, practice-oriented review of contract theory.

The outline of the chapter is as follows. In section 2.2, we discuss how to systematically address the many elements of contract design. The contracts we use to exemplify our rules are briefly surveyed in section 2.3. The ten rule of thumb are then defined and exemplified in the main section of this paper, section 2.4. Conclusions are provided in section 2.5.

2.2 Contract Design

Handling the complexity of real world contracting requires a systematic approach. In this chapter we develop such an approach in terms of a checklist or guideline for contract design. A good guideline has a number of properties. To be relevant, the guideline must be comprehensive and cover the main issues involved. To be useful, it must link the general concerns with more specific means. Lastly, to be applicable, the guideline must show how to balance the different concerns and means.

To guarantee a *comprehensive* coverage, it is helpful to step back and recall the general design issues identified in the economic literature[4]. All economic systems –

[2] See chapter 4-5.
[3] See chapter 6.
[4] See for example Milgrom and Roberts (1992).

except simple Robinson Crusoe systems – involve several agents with conflicting interests, private information and private possibilities to act. From the point of view of specialization, one can even argue that the decentralization of information and decision-making among different agents is what gives a system the potential to operate more efficiently than a single individual. Specialization however comes at a cost. Information must be shared and actions must be coordinated. There are three aspects of this:

- **Coordination:** ensure that the right products are produced at the right time and place (rules 1-3 on the checklist).
- **Motivation:** ensure that the contracting parties have individual incentives to make socially desirable decisions that maximize the total integrated profit (rules 4-8).
- **Transaction costs:** ensure that coordination and motivation are provided at the lowest possible cost (rules 9-10).

To give a useful list, we will link the general concerns with the more specific *means and instruments* in the contract designer's toolbox. We will cover primary coordination tools like instructions, prices, allocation of decision rights and sharing of risks. Also, we will discuss alternative motivation tools like incentive schemes, contract menus, repeated contracts and renegotiation mechanisms. Finally, we will discuss ways to reduce transaction costs like low information requirement, infrequent negotiations, arbitration, reputation building as well as the use of simple and transparent contracts.

The different concerns in contract design may conflict and the different means may have both desirable and non-desirable effects. The different objectives must therefore be *balanced*. The checklist is an instrument for clarifying the necessary trade-offs. In some cases, coordination is the primary concern, e.g. because of perishable products that requires fine synchronization of harvesting and processing. In other cases, the motivational issues are at front, e.g. because of potential lock-in effects with resulting under-investments. In general, we cannot say which trade-offs are the optimal ones. It depends on the context, including the technology, the preferences of the parties involved, and the distribution of information. For specific problems, we can describe the contexts in details and then discuss the relevant trade-offs. We have done so for specific sectors[5] but it by and large requires a full paper for every sector. It is therefore not a road we can pursue in any details here.

Our methodological approach is to consider contract design as a multiple criteria decision problem. We identify the spectrum of alternatives, i.e. the different means, and the set of relevant criteria, i.e. the concerns. We seek comprehensive descriptions of means and ends and we suggest that this holistic approach in itself, and in particular when coupled with context specific information about the relative impor-

5 See chapter 4 and 5.

tance of the objectives, will lead to superior designs of the structure and institutions[6].

2.3 The Contracts

We have studied contracts representing a broad spectrum of the agricultural sectors in Denmark. The contracts cover different ownership structures. Some contracts illustrate the problems of introducing contract production in cooperatives with heterogeneous producer groups. Other contracts illustrate the conflicts between producers and investor-owned firms in the food industry.

The contracts we have studied cover the following sectors:

- **Peas:** contracts between producers of consumption (green) peas and the investor-owned Danisco Foods[7]. The contracts facilitate precise coordination and provide risk-sharing through group standards[8].
- **Special Pigs:** contracts between Denmark's largest slaughterhouse, Danish Crown, and producers of special pigs (e.g. UK pigs, free range pigs and organic pigs). Danish Crown is a cooperative and the contracts reflect some of the difficulties in contracting with different producer groups within a cooperative[9].
- **Eggs:** contracts between the cooperative Danæg and producers of battery eggs, deep litter eggs, free-range eggs and organic eggs, respectively. The contracts coordinate the combating of disease at the different levels of production[10].
- **Broilers:** contracts between private producers and the investor-owned Rose Poultry[11]. The contracts ensure a high level of food safety through the tight control of inputs.
- **Fruit and Berries:** contracts between producers of blackcurrants and cherries and the investor-owned processor Vallø Saft[12]. The contracts facilitate both coordination and usage of local information in the harvesting process.
- **Grass and Clover Seed:** contracts between producers and the three major processors in the industry: DLF Trifolium (a producer-owned cooperative with a market share of 74 per cent of the Danish production), Hunsballe Frø (owned by a private foundation), and the investor-owned Wibollt, both with a market share

[6] We have successfully used similar multiple criteria decision making approaches to the design of payment plans in other sectors as well. See for example Bogetof and Olesen (2000) and Bogetoft and Pruzan (1997).
[7] In 2000 Danisco Foods was sold to the Belgian company Ardo. This paper describes the situation before Danisco Foods was sold.
[8] The contract is described in Danisco Foods (1998), Sørensen (1998) and Grower Association (1998). Chapter 4 gives an in depth analysis of the contract.
[9] The primary sources for the analyses of this contract are Danish Crown (200a+b) and Andersen and Villadsen (1999).
[10] See Danæg (2000).
[11] See: Rose Poultry (2000) and The Danish Competition Council (2000).
[12] See Vallø saft (1999) and Bjerregaard et. al. (1999).

of 12 per cent. The contracts are very similar. However, some of the contract details reflect the differences in ownership structures[13].

- **Sugar Beet:** contracts between producers and the investor-owned Danisco Sugar. The production of sugar is highly regulated in the EC. The producers have non-tradable production quotas[14].
- **Potatoes:** contracts between producers of potatoes and their cooperative AKV Langholt. The potatoes are processed into starch. The total quantity is regulated through tradable production rights[15].

Table 2.3.1 gives a summary of the contracts, the key problems in the context they are designed for, and the some of the main coordination, motivation and transaction costs tools they apply. Although the summary is crude, it may facilitate the understanding of the examples in the next section, where we will usually just point to one or a few characteristics of the different contracts.

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[13] See DLF Trifolium (1998), Nissen et. al. (1999), Hunsballe (1996), Kisselhegn (1999), and Wibolt (2000).
[14] See Danisco Sugar (1996).
[15] See AKV Langholt (1991, 2000) and Bjerrum (2001).

Contract	Key problems	Coordination	Motivation	Transaction costs
Peas	- Synchronize harvest	- Centralized decision-making - Tournaments - Minimum payment	- Tournaments	- Producer association - Advising - Inspections
Special pigs	- Transport cost - Traceability - Adjust supply	- Geographic restrictions	- Market-determined bonus - Quality bonus	- Limit information - Advising
Eggs	- Disease control - Adjust supply - Traceability	- Production schedules - Mandatory reduction of flocks	- Quality bonus	- Regular testing
Broiler	- Synchronize slaughtering - Disease control	- Processor determines the production schedule	- Quality bonus	- No monitoring
Fruit	- Synchronize harvest - Use local information on ripeness	- Decentralized decision making - Processor can delay harvest - Forecast on harvest	- Quality bonus	- Advising
Grass and Clover	- Ensure quality - Control supply	- Total acreage limited by the contracts	- Quality bonus	- Advising - No pooling of income
Sugar Beet	- EC sugar regulation	- Non-tradable production rights - No side-trading	- Quality bonuses - Penalties outside delivery tolerance	- Producer association
Potatoes	- EC quota at firm level - Ensure quality	- Tradable production rights - Side-trading allowed	- Quality bonus - Penalties outside delivery tolerance	- No monitoring - Advising

Table 2.3.1 Survey of eight contracts

2.4 Ten Rules of Thumb

In this section we define the ten rules of thumb for contract design. We also provide a series of examples that illustrate how the rules have been implemented in real contracts. The ten rules of thumb are:

1. **Coordinate production:** It is important to coordinate the actions of independent decision-makers. This coordination can be achieved either through instructions or through price signals.

2. **Balance the costs and benefits of decentralization:** The decision-making rights should be allocated so that decisions are coordinated, costly communication is minimized and important information is utilized.
3. **Minimize the costs of risk and uncertainty:** The costs of risk and uncertainty can be reduced through risk minimization and risk sharing.
4. **Reduce the costs of post-contractual opportunism:** Often the processor cannot observe the actions taken by the producers after the contract has been signed. The contract should motivate the parties to take the right actions.
5. **Reduce the costs of pre-contractual opportunism:** Often the producers (or the processors) have private information about their skills, cost structure etc. before the contract is signed. This may lead to the adverse selection problem and may enable producers to obtain information rents.
6. **Do not kill cooperation:** The contract should induce cooperation and the sharing of information about production techniques, etc. However, cooperation can give rise to influence costs from activities designed to influence the decisions of others in a self-interested fashion.
7. **Motivate long-term concerns:** The contract should induce the parties to take the long-term effects of their actions into consideration.
8. **Balance the costs and benefits of renegotiation:** Renegotiation facilitates flexible contracts, but reduces the commitment and may lead to strategic behavior.
9. **Reduce the direct costs of contracting:** The direct costs of contracting are the time and money spent on information collection, monitoring, bargaining, conflict resolution etc.
10. **Use transparent contracts:** The contracts must take account of the parties' bounded rationality. It is important to use simple contracts, so that the parties easily can relate the incentives to their decisions.

The individual rules are expanded upon below.

2.4.1 Coordinate production

Perhaps the most important role of contracts is to coordinate the actions of independent decision-makers. After all, the reason to cooperate is to create shared value through joint actions. Also, if one can increase the value from joint actions, it is easier to sustain the cooperation since there will be less temptation to terminate it and seek alternative partners etc.

Coordination must ensure that the production is optimized throughout the entire production system. Lack of coordination leads to sub-optimization where decision-makers “optimize” their own decisions without considering all the consequences they have for other decision makers in the production chain[16].

An important aspect of coordination is the minimization of production costs. Producers with lower marginal costs should be allocated a larger share of the production. This allocation problem can be solved in different ways. One method is the market approach where the producers compete for the right to produce, e.g. through an auction of tenders. Another approach is the central planner approach. In this, a planner (usually the processor) directly chooses the producers and possibly their production levels.

Coordination can generally be achieved using instructions, or price signals or some combination of the two. It is often attractive to coordinate qualitative aspects via instructions and quantitative aspects via prices. Matching and synchronizing problems are often coordinated via instructions while production levels are often coordinated via prices.

Examples

The contracts we have studied have different approaches to quantity control. Biological uncertainty etc. makes it impossible to control agricultural production completely. Therefore, the contracts allow for some flexibility in the quantities delivered. For instance, in contract production of sugar beet the producers receive a reduced price (C-price) for quantities above the contracted quantity. The contracts for special pigs allow for the deliveries during a five-week period to vary ± 30 per cent. On the other hand the contracts for potatoes specify a fixed quantity, which the producer (in principle) must deliver. AKV Langholt can buy any shortfall at the producer’s expense, if a producer does not fulfill his contract[17]. The contracts for fruit and berries, grass and clover, and peas only control the acreage used in the production. The yield per hectare is influenced by price mechanisms.

Harvesting perishable products creates a synchronizing problem. The products require processing soon after harvest. The products may be spoiled, if the harvesting is not coordinated according to the processor’s capacity. Often coordinating harvesting and processing is more important than choosing the best time for harvesting, when considered in isolation, i.e. when the products have the highest yields, the best ripeness etc. For this reason the harvesting of perishable products is often coordinated through instructions. The harvesting of peas, fruit and berries, and broilers are all coordinated through instructions. On the other hand harvesting of storable products does not require synchronization. Therefore the harvesting of potatoes, sugar beet, and grass and clover seed is not coordinated in the contracts we have studied.

[16] See Milgrom and Roberts (1992) and section 3.4 for detailed discussions of the coordination aspect in contracts.

[17] This rarely happens, though.

The problem of allocating production to the most efficient producers is solved in different ways. The production rights on potatoes produced for AKV Langholt are tradable, i.e. the market mechanism ensures that the producers with the lowest production costs own the contracts. On the other hand the production rights on sugar beet are non-tradable. This means, that the contracts for sugar beet do not ensure that the most effective producers undertake the production. A more serious problem arises when the processor decides to close a factory. This increases the transport costs significantly. After the closing of Gørlev Sukkerfabrik in 1999, Danisco Sugar bought the production rights of producers near the closed factory and resold the production rights to producers near one of its existing factories.

The production of special pigs is restricted geographically. This means that only producers within a certain distance of the slaughterhouse, where the particular special pig is slaughtered, can produce the special pig in question. This rule was introduced to reduce the transport costs, which are paid by the slaughterhouse. The geographical restriction means that the special pigs are not necessarily produced at the lowest cost farms. However, the regional differences in the producers' cost structures are probably small. Hence, the problem of minimizing transport costs is probably more important than the issue of allocating production between farmers efficiently. In theory, allocating the special production by auctioning the production rights and having the producers pay the transport costs can lead to efficient production, where both production and transport costs are minimized. However, such an auction is difficult to implement due to a number of practical problems, cf. Bogetoft and Olesen (2000).

2.4.2 Balance the costs and benefits of decentralization

The allocation of decision rights is a key aspect of a contract. A contract is decentralized if the producers have authority to take most of the decisions. On the other hand, if a contract gives the processor authority to take most of the decisions, the contract is centralized. In practically all contracts some decisions are centralized and some decisions are decentralized.

When designing a contract the parties should aim for the decisions to be made by the informed party. When only the producers possess the information relevant to a decision, the contract should either give the producers authority to make the decision or motivate the producers to summit their information to the processor, so that he can make the decision on an informed basis.

There are two immediate benefits of decentralization. Firstly, decentralized contracts in which the informed party makes the decision reduce the risk of important information being neglected in the decision-making process. Secondly, decentralized contracts can reduce the need for costly communication.

On the other hand, a decentralized contract may increase the risk of un-coordinated decisions-making. Decentralized decisions may lead to serious matching and synchronizing problems, cf. section 2.4.1[18].

The information requirement is an important criterion when determining the level of decentralization in a contract. It is costly to collect and process information. Therefore, a good contract minimizes the information requirement. For a contract to work, information is required by both processor and producers, and shifting the information requirement does not solve the problem of obtaining the necessary information. We return to the information requirements in section 2.4.9 and 2.4.10.

Decentralizing the decisions may create motivation problems. Thus, if a contract delegates the decision rights to the producers, it is important for the contract to give the producers the right incentives so that the moral hazard problem is minimized (we discuss the moral hazard problem in section 2.4.4). However, centralizing the decisions can promote opportunistic behavior by the processor. Centralizing the decision rights may cause hold-up problems, if the producers are locked-in by specific investments. We discuss hold-up problems in section 2.4.7.

The allocation of decision rights can be used to reduce the problems of pre-contractual opportunism and thereby reduce information rents arising from adverse selection problems (we discuss adverse selection problems in section 2.4.5). If the processor determines the levels and characteristics of some inputs (e.g. by supplying the inputs), a producer has less possibility of mimicking other producer types[19]. In other words, low skilled producers have less possibility of mimicking high skilled producers, if the processor provides some of the inputs.

The costs and benefits of decentralizations are summarized in the table below.

Problem	Decentralization	Centralization
Use all important information	+	
Communication	+	
Coordination		+
Information requirement	+	+
Moral hazard		+
Hold-up	+	
Reduce information rents		+

Table 2.4.1 Cost and benefits of decentralization

Examples

In contracts for the production of berries for Vallø Saft the producers have more information than the processor about the ripeness of the berries because the produ-

[18] Milgrom and Roberts (1992) discuss the pros and cons of decentralization.

[19] See Goodhue 1999 and 2000 for applications of this idea to agricultural contracts in the US.

cers can inspect their fields directly, i.e. the producers are better informed about the optimal harvesting time than the processor. Therefore, the contract delegates the right to decide the harvesting time to the producers.

The harvesting of berries must be coordinated to avoid capacity problems at the factory, because the berries perish unless they are processed or frozen within few days after the harvesting. Hence, complete decentralization of harvesting decisions may lead to coordination problems due to capacity constraints. The contract solves this issue in a simple and very effective way. The producers must use boxes supplied by Vallø Saft for harvesting. In reality this enables Vallø Saft to control the harvest in case of capacity problems at the factory. Vallø Saft can delay the harvest by delaying deliveries of boxes to the producers.

The contracts for the production of berries for Vallø Saft lead to the optimal allocation of decision rights both with and without capacity problems at the factory. When there is no capacity problem, the most important issue is to utilize the local knowledge about the ripeness of the berries without costly communication. Therefore, the decisions on harvesting are decentralized when there is no capacity problem. On the other hand, when there are capacity problems the most important task is to coordinate the harvest in order to avoid oversupply of harvested berries. Therefore, decision-making on harvesting is centralized when there are capacity problems.

The production of peas for Danisco Foods is another example, where coordination is the most important issue. The peas must be harvested within a 24-hour window. If the peas are harvested too soon, the yield will be too low. If the peas are harvested too late, the taste will be ruined because the peas will be too ripe. Once harvested, the peas must be frozen within 4 hours to remain fresh. Thus the production requires precise coordination. In order to ensure coordination, most of the decisions are centralized. Danisco Foods decides:

- who to accept as producers
- when the peas shall be sown (done by the producers)
- when the peas shall be harvested (done by Danisco Foods)

The contracts for the production of peas also illustrate that centralization can reduce the moral hazard problem. Danisco Foods supplies the peas for sowing. This removes the potential moral hazard problem of the producers sowing too many peas per hectare, since the growers cannot buy the peas elsewhere.

Centralized decision-making also reduces the moral hazard problem in the contract production of eggs for Danæg. The contract specifies that the producers must buy their chicks and their feed from suppliers approved by Danæg. This eliminates the producers' possibility of using cheaper inputs with lower food safety standards.

2.4.3 Minimize the costs of risk and uncertainty

Agricultural production involves a number of different types of risks. Biological risk is inherent in agricultural production. Typically agricultural production also involves large price risks (on both input and output prices). Agricultural production is also affected by political changes (e.g. changes in environmental, trade, tax or agricultural policy). This is called the institutional risk. In addition to these types of risk there is behavioral uncertainty. In many cases one party (e.g. the processor) does not know what actions the other party (e.g. a producer) takes.

Normally an uncertain payment is considered less valuable than a certain payment with the same expected value, i.e. risk and uncertainty are costly. In general the parties can reduce the cost of risk and uncertainty in two ways. They can design a contract that minimizes the risk and they can share the risk between them.

Producers are often small family businesses with limited possibilities for diversifying investments. This makes the producers vulnerable to risk. Therefore, it is reasonable to assume that producers are willing to sacrifice some expected income in exchange for reduced uncertainty, i.e. the producers are risk averse. The processor often has a diversified production with several business lines. The owners of the processor can diversify their investments in the capital market. Thus, the typical assumption in contract theory is that processors are less risk averse than producers. This means that processors can bear the risk more cheaply than producers.

When the producers own the processor (a producer cooperative) the risk cannot be shared between producers and processors because they are the same people. However, some risk sharing is still possible. Firstly, most cooperatives process more than one product. This means that the cooperative can share risks between producers of different products (producer groups). Secondly, the equity in the cooperative can be used as a buffer to absorb fluctuations in profits[20].

If the producers are risk averse and the processor is risk neutral, the efficient way to share risk is to place all the risk on the processor so that the producers receive a fixed salary. However, in order to motivate the producers to take unobservable actions the payment must depend on the output, cf. 2.4.4. In other words, there is a trade-off between risk sharing and incentives. An efficient contract balances the costs of risk bearing against the incentive gains[21].

There is no trade-off between risk sharing and incentives for some types of risk. Common risks affecting all producers equally, regardless of the producers' actions, can be removed from the payment scheme without affecting the incentives. This is one of the rationales for relative performance evaluation[22]. Similarly, it may be pos-

[20] For a more detailed discussion of the possibilities for risk sharing in cooperatives, see Hansmann (1996) and Bogetoft and Olesen (2000).
[21] Cf. Holmström (1979) and Milgrom and Roberts (1992).
[22] See Holmström (1981), part 3 of this thesis, and section 3.5.2 for analysis of relative performance evaluation.

sible to remove price risk from the producers' payments without affecting their incentives.

The parties can minimize the risk and uncertainty in different ways. One way is to choose a robust contract that leads to reasonable outcomes even if the initial assumptions do not hold true. Information collection (monitoring) is another way of minimizing risk and uncertainty[23]. The parties can reduce the measurement errors through the sampling design, e.g. by using multiple spot checks.

The length of the contract affects the risk[24]. Long-term contracts based on fixed prices are like a lottery, where the future level of inflation determines the winner. Contracts based on price indexes or short-term contracts can reduce this risk. However, short-term contracts may increase behavioral uncertainty (e.g. the hold-up problem, which we describe in section 2.4.7).

Examples

One example of relative performance evaluation is the contract for the production of berries for Vallø Saft. For each percentage point by which the content of dry matter is above (or below) the average, the price to the producer is increased (or reduced) by 0.5 per cent. The total payment from Vallø Saft to the producers is unaffected by the average quality of the Danish harvest. Hence, Vallø Saft bears the general risk of the quality of the berries.

Another example of relative performance evaluation is the contract for the production of peas for Danisco Foods. The producers are divided into groups based on the time of sowing, so that all producers in one group have the same weather conditions and use the same variety[25]. The average payment per hectare is the same for all groups. Hence, the expected payment to a grower is independent of the time of sowing. Within the group the payment is distributed in proportion to the quantity produced, i.e. through relative performance evaluation.

The cooperatives choose different approaches to risk sharing. DLF-Trifolium keeps the profits from different species of seed separately. There is no transfer of profits from one producer group to another producer group (e.g. from the producers of red clover seed to the producers of blue Kentucky grass seed), i.e. there is no risk sharing between different producer groups.

In contrast, Danish Crown pays a fixed bonus to the producers of UK pigs. The bonus does not depend on the actual price differential between the UK market and the world market. The bonus for UK pigs is also independent of how large a share of the UK pigs are actually sold as UK pigs and not as ordinary pigs. Hence, the producers of UK pigs may be subsidizing the ordinary producers, when the demand on

[23] See Milgrom and Roberts (1992) and section 3.6.3 for a discussion of monitoring as a way of reducing the risk. Information collection and monitoring is discussed in further detail in section 2.4.9 about the direct cost of contracting.

[24] Cf. Hart (1995).

[25] The variety and the time of sowing is determined by Danisco Foods.

the UK market is high, and vice versa when the demand on the UK market is low. This provides risk sharing between the producers of UK pigs and the producers of ordinary pigs.

The contracts also illustrate different ways of minimizing the risk and uncertainty. In a number of contracts the producers can require a second spot check to be analyzed by a neutral third-party, if they question the first test result. The double testing reduces measurement errors. The option of having a second analysis made also reduces the behavioral uncertainty of the processor cheating via the test results. Multiple analysis of the products is used in the grass and clover industry, in contracts for sugar beet and the contracts for potatoes.

Placing the risk at the right stage of the production chain is another way of reducing the risk. If a processor goes out of business the producers may loose their marketing channel, i.e. the bankruptcy of a processor may lead to severe losses for the producers. On the other hand, if a producer goes bankrupt it is easy for the processor to find a replacement. Hence, the spillover effect from a producer's bankruptcy is small. Therefore, reducing the risk of processor bankruptcy may reduce the total risk. This argument is used by Vallø Saft, DLF-Trifolium and Hunsballe Frø when they explain the rationale behind the risk sharing in their contracts[26].

2.4.4 Reduce the costs of post-contractual opportunism

Often the processor cannot observe the actions taken by the producers after the contract is signed. Opportunistic producers do not automatically take the actions called for in the contract. This is what the literature refers to as the moral hazard problem. The contracts should motivate the producers to take the right actions, even if they are unobservable[27].

In order to provide incentives for unobservable actions, the compensation to producers must be based on outcome. However, usually there is a stochastic relationship between the actions and the resulting output. This implies that output-based incentives will expose the producers to risk, because the payment depends on factors like the weather which the producers cannot control. When the producers are risk averse, this risk carries a risk premium. Hence, there is a trade-off between providing incentives and minimizing the cost of risk, cf. section 2.4.3.

If the processor can obtain better information about the producers' effort, he can expose the producers to less risk – and still induce the producers to provide the same

[26] A similar pattern is seen in many agricultural contracts in the US, where the producers bear the environmental responsibility (Hayenga et. al., 2000). This means that victims of pollution can only raise claims against the producer and not against the processor. Typically the producers have much less capital than the processor. This may limit the effective compensations paid to victims of pollution. Thus, placing the environmental responsibility on the producer can minimize the total risk in the contract.

[27] The contracts must respect the incentive compatibility constraint, which states that the producers choose the actions that maximize the producers' own utility.

inputs. According to the informativeness principle, any performance measure which reduces the error in estimating the producer's effort should be used in the contract[28]. This implies that the payment to a producer should depend on information about the performances of other producers, if this gives a more precise estimate of the effort provided by the producer in question (e.g. due to common risk).

A number of factors determine the optimal strength of the incentives. The optimal strength of the incentives primarily depends on three factors[29]. First, the incentives should be strong if the additional effort has a high value, i.e. increases the integrated profit considerably. Second, the incentives should be strong if incentives have strong effect on the producer's behavior. Third, the trade-off between providing incentives and reducing the costs of risk means that the incentives should be weak if the producer is very risk averse or if the processor only has very imprecise information about the producer's behavior.

Often producers undertake different tasks simultaneously, e.g. production of quantity as well as quality. In such situations a rational producer will tend to ignore less well-paid tasks and focus on the more generously rewarded ones. To avoid this problem, the incentives must be balanced. Consider a producer who has to allocate his time to two different tasks. The producer's disutility per time unit is the same for both tasks. The equal compensation principle[30] states that if the allocation of time between two activities cannot be measured:

- Either the marginal rate of return must be equal for both tasks
- Or the activity with the lower marginal rate of return receives no time

Examples

Delivery of the entire production can be a moral hazard problem. If the processor only has imprecise information about the size of the production, a producer may be tempted to sell his produce elsewhere if he can receive a better price for his produce outside the contract. This problem actually occurred to Vallø Saft. The firm used to offer contracts with minimum prices to producers. When the market price was below the minimum price, deliveries from the producers receiving the minimum price were very high while deliveries from producers receiving the lower market price were very low. This indicates that there was a problem of side trading, where the producers receiving the market price sold their berries to the producers receiving the minimum price. For this reason, Vallø Saft no longer offers minimum price contracts.

The production of special pigs involves a number of moral hazard problems. It is costly for the slaughterhouse to monitor whether the producers follow all the rules in the production of special pigs. Therefore the monitoring is based on spot checks.

[28] Cf. Holmström (1979).
[29] Cf. Holmström (1979).
[30] See Milgrom and Roberts (1992) and section 3.5.2.

This means that the producers may be able to cheat without being caught (e.g. by not using the right feed). The producers are motivated to take the right unobservable actions because of the risk losing the bonuses they have received already and their right to produce special pigs if a spot check reveals cheating.

The production of pigs also illustrates a classic multi-task problem, where the slaughterhouse wants to motivate the production of both quantity and quality. The producers can affect the meat quality in a number of ways: feeding, breeding, pigsty systems etc. It would be very costly for the slaughterhouse to monitor the behavior of the producers, so the incentives are based on output measures. The value of the meat depends on quality parameters such as fat content, taste, color, consistence, homogeneity, etc. Several of these quality parameters, e.g. taste, cannot be measured. Therefore Danish Crown uses two parameters to measure the quality: meat percentage and slaughter weight[31]. These parameters are positively correlated to the other quality parameters like taste and consistence. Thus, the slaughterhouse motivates the producers to supply high quality pigs (right taste, color, consistence etc.) by motivating production of pigs with the right slaughter weight and a high meat percentage.

2.4.5 Reduce the costs of pre-contractual opportunism

A producer only signs a contract, if the contract gives him an expected profit at least equal to his reservation value, i.e. the profit from his best alternative option. This is the individual rationality constraint. In order to maximize his own profit the processor tries to design the contracts so that each producer receives exactly his reservation value. If a producer has private information about his skills, cost structure etc. before the contract is signed, he may be able to obtain a contract giving him an expected profit above his reservation value (i.e. he earns information rents). This is the problem of pre-contractual opportunism[32] or adverse selection[33].

The literature on contract theory points to four ways of reducing the adverse selection problem. The first solution is for the processor to collect information before the contract is signed. In this way the processor can reduce the producers' informational advantage. A second approach is signaling, where the producers reveal their true type through their behavior before the contract is signed. The third way is rationing, where the processor only offers a contract acceptable to some ("good") the

[31] In short, the incentives are: for each percent point by which the meat percentage is above (or below) 59 percent the price is increased (or reduced) by DKr. 0.10. For each kilogram the slaughter weight deviates from the optimal interval (67-79 kg.), the price is reduced by DKr. 0.10 per kg.

[32] See Akerlof (1970), Salanie (1997), Milgrom and Roberts (1992) or part 2 of this thesis for detailed analysis of pre-contractual opportunism.

[33] Adverse selection problems can also occur if the processor is prevented from using information about the agents' type. Part 3 of this thesis analyzes differences between post-contractual opportunism caused by private information and post-contractual opportunism caused limitations in the possibility of using information about the producers' type.

producer types, so the producers' abilities to extract rents by mimicking worse types are reduced. In this way rationing leads to fewer but better contracts. The fourth approach is screening. Screening is a milder form of rationing. The processor can screen the producers by offering them a menu of contracts. The contracts must be designed so that the producers reveal their true type through their selection of contract.

Examples

One example of pre-contractual opportunism is the case of the production of berries. Previously, the contract did not reward (or penalize) producers of high (or low) quality fruit and berries. As a consequence, producers used to sign the contract even though their fields were not suited to high quality production of berries. Later on the contract was changed so that producers with high quality berries received a higher price, cf. the discussion of relative performance evaluation in section 2.4.3. This change meant that producers with fields not suitable for berry production no longer sign the contract. Hence, Vallø Saft has used rationing and signs fewer but better contracts.

Vallø Saft's experiences from contracts for fruit and berries also illustrate the use of screening. As mentioned, Vallø Saft used to offer a contract with minimum prices. In this way the producers revealed their risk attitude though their choice of contract. The risk averse producers chose minimum-price contracts (with lower expected payment), while risk neutral producers chose to trade at market prices. In this way Vallø Saft could provide efficient risk sharing, cf. section 2.4.3. However, offering minimum prices created a moral hazard problem due to side-trading as discussed in section 2.4.4, i.e. Vallø Saft's experiences illustrate the important point that solving one problem in a contract can create other and more severe problems.

Danisco Foods inspects the fields before signing contracts for the production of peas. In this way Danisco Foods reduces the problem of post-contractual opportunism caused by asymmetric information.

The contract between Danisco Foods and the pea producers also illustrates a problem similar to adverse selection created by restrictions in the use of information. The pea producers prevent Danisco Foods from using information about their soil quality and field size in the contract. This means that Danisco Foods must raise the payment to all producers, if Danisco Foods wants to attract producers with high reservation values (e.g. due to good soil quality or large fields). This enables the pea producers to obtain compensation above their reservation values[34].

When the producers of grass and clover seed are selected, the processors consider the producers' general performances in crop production. This means that a producer can signal his skills through his performance in general crop production.

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[34] The problem is analyzed in chapter 4 of this book.

2.4.6 Do not kill cooperation

The parties can only achieve the full economic benefits from their production if they cooperate. The producers can help each other by sharing know-how, exchanging favors etc. Flexibility from both producers and processors may enable the parties to adjust to events not accounted for in the contract. Hence, it pays for the parties to work in a cooperative spirit where changes can be made without costly negotiations or conflict resolution.

Using strong incentives complicates the cooperation between the processor and the producer, because the payment will be very sensitive to the decisions taken by the other party. For instance, a producer may protest when the processor changes his delivery time in order to ensure an appropriate flow at the factory, if the change has huge impact on the producer's payment.

Incentives based on relative performance evaluation[35] may have a negative impact on the cooperation between producers. Lazear (1989) argue that relative performance may induce producers to sabotage other producers.

Often producers have better information about other producers' behavior than the processor. Group incentives, where the total payment to a group depends on the performance of the entire group, motivate the producers to monitor one another and perhaps impose some kind of social penalty (e.g. a bad reputation in the neighborhood)[36]. Producer cooperatives are extreme examples of group incentives.

Cooperating can give rise to influence costs. Influence costs arise from activities designed to influence the decisions of others for self-interested purposes. Influence costs can be reduced through limiting communication or limiting the number of decisions[37].

In order to exploit the synergies of cooperatives, the contract must ensure that no producer group has an incentive to break away from the cooperative to form their own cooperative instead (e.g. a cooperative for organic producers)[38]. This means that the profit that a producer group earns within the cooperative must be larger than or equal to the profit the producer group can earn outside the cooperative.

Examples

The contracts use different mechanism to share know-how between the producers. Most of the companies (e.g. DLF-Trifolium, Danisco Foods, Vallø Saft, and Danish Crown) provide consultancy for the producers. The consultants broadcast experiences to other producers. Some companies (e.g. AKV Langholt, DLF-Trifolium, and

[35] Cf. section 2.4.3.
[36] Cf. Milgrom and Roberts (1992).
[37] For a comprehensive discussion of influence cost see Milgrom and Roberts (1990) and Hansmann (1996).
[38] See Bogetoft and Olesen (2000) for a detailed analysis of the problem. Influence cost is a type of transaction costs. Hence, there is both a motivational and a transaction cost aspect of the cooperation concern.

Danish Crown) facilitate dispersion of know-how through newsletters. A producer meeting is another way of spreading know-how about production techniques etc. (this approach is used by AKV Langholt and DLF-Trifolium).

The cooperative, DLF-Trifolium, can order producers to plough up their fields in order to reduce the total supply of seed. The contracts for production of grass and clover seed for the two private companies, Hunsballe and Wibollt, do not have this option. This illustrates an interesting point. The higher the goal-congruence between the producers and the processor, the easier it is for the parties to cooperate. The reason is that the risk of DLF-Trifolium misusing its authority to order reploughing is small because the producers control the cooperative, whereas the risk of private companies misusing the same authority would be higher[39]. Hence, it seems to be easier for the cooperative to determine the production plan in a cooperative spirit.

The contracts for the production of eggs for the producer cooperative Danæg give the processor a similar authority to regulate supply. Danæg can require a producer to slaughter part of his flock of hens if the total supply is too high.

One way of reducing influence costs is by limiting the communication, thereby preventing effective influence activities. The producers cannot obtain precise information about Danish Crown's profit on special pigs. Similarly, only the processor has information about the earnings on different types of seed in the grass and clover industry. These cases show how limiting communication can reduce influence costs, because the producer groups do not have the information required for serious discussion of the distribution of payments to different producer groups.

Danish Crown uses market-determined bonuses to ensure satisfactory payment to different producer groups, so that no producer group has an incentive to break away from the cooperative. With market-determined bonuses, payment to the special producers increases when the demand for special pigs is high and falls when the demand is low. Thus, the market-determined bonuses reduce the risk of one producer group (e.g. producers of ordinary pigs) earning lower profits within the cooperative than it could earn outside the cooperative.

2.4.7 Motivate long-term concerns

The contract should induce the parties to take the long-term effects of their actions into consideration.

It is important that the contract encourage the right investments. Often production and processing require specific investments, i.e. assets with a lower value in their best alternative use. A party who has invested in specific assets is vulnerable to termination of the contract. This leaves the party with specific assets in a weak bargaining position in negotiations after the investment has been made. Hence, the opponent can obtain better terms than originally agreed by threatening to terminate

[39] See Hansmann (1996) for a more complete discussion of a similar finding.

the contract. Of course, the parties foresee this and are reluctant to make specific investments. This is the hold-up problem.

The hold-up problem can go both ways, i.e. both the processor and the producers can hold-up the other party. However, a processor can normally replace one producer with another without large costs. Thus, the hold-up problem is usually most significant when the processor holds-up producers.

The hold-up problem can be reduced in different ways. Firstly, long-term contracts reduce the hold-up problem because the terms are settled before one of the parties makes specific investments. In practice, however, it is impossible for the parties to make complete contracts that cover all possible eventualities, i.e. the contract always leaves some questions open to negotiation, with the possibility of hold-up even in long term contracts. Secondly, if both parties make specific investments the balance in the bargaining positions can remain unchanged. Thirdly, the role of reputation may prevent the parties form holding-up the other party. A party (e.g. the processor) with a good reputation may be reluctant to devalue this reputation by holding-up a contract party, because this may ruin his chances for making contracts with other agents[40].

A long-term contractual relationship gives alternative reward and punishment mechanisms from termination of the contract to renewal of the contract.

In a long-term relationship the parties can obtain better information. Revealing the information in the first period may enable the processor to extract all the profits in subsequent periods. Hence, a producer may require a large payment to reveal his private information. This can lead to the ratchet effect. The ratchet effect is less severe if the processor forces the producers to compete and thereby reveal their private information[41].

The parties can use a long-term contract to perform planned experiments (e.g. field tests) and thereby increase their know-how. In order to obtain the best know-how about production, the producers should act differently, i.e. experiment. The long-term contract can facilitate such experimental behavior.

Examples

In most of the contracts in our study we find no indication of hold-up problems. In many cases the producers can sell their products through alternative channels. This reduces the asset specificity, because the assets have almost the same value for the producer, as if he had signed a contract with another processor. This is the case in production of grass and clover seed, fruit and berries, eggs, and potatoes.

[40] See Hart (1995) for a comprehensive analysis of the hold-up problem.

[41] This is the general idea in Shleifer (1985) and similar to the result known as the agricultural treadmill. See also section 3.5.2.

Danisco Foods is the sole processor of consumption (green) peas in Denmark, but the producers do not invest in specific assets. Thus, there is no hold-up problem in the production of peas.

Producers of broilers usually sign contracts with a 2-year notice of termination. The contracts do not specify how the base payment is determined, i.e. Rose Poultry is free to change the price paid to the producers. This could enable Rose Poultry to hold-up the producers for a 2-year period. However, the importance of Rose Poultry's reputation prevents such behavior.

The contracts for the production of peas for Danisco Foods facilitate experiments. Danisco Foods can order a producer to try out a new variety on a part of his field. The production of the new variety is settled in the usual way. However, the producers are guaranteed to receive at least the same payment per hectare for the new variety as they receive for the normal variety.

2.4.8 Balance cost and benefits of renegotiation

Renegotiation facilitates flexible contracts and enables the parties to adjust the contract to changes in the environment. Hence, the parties can remove ex post inefficiencies through renegotiation. However, renegotiation also reduces commitment and may lead to strategic behavior[42].

The problem of renegotiation is that, if the parties know that the contract is to be renegotiated, the parties do not act according to the incentives in the initial contract but according to the incentives they expect to receive in the renegotiated contract. Hence, renegotiations can lead to ex ante inefficiencies[43]. Often powerful incentives rely on harsh penalties that are costly for both parties to implement, i.e. ex post both parties can be better off if the penalty is removed. If the parties foresee this as the result of renegotiation, the incentives will be weakened.

The hold-up problem discussed in section 2.4.7 is an example of how incomplete commitment can lead to ex ante inefficiencies. The hold-up problem occurs when the parties cannot commit to the trading terms.

In section 2.4.3 we discussed the trade-off between risk sharing and incentives. If the parties renegotiate after the effort has been provided, the parties can improve the ex post efficiency by shifting the risk from risk averse producers to a risk neutral processor. However, the incentives vanish if the producers expect this to happen.

Examples

Danisco Foods' contracts for peas illustrate an interesting point about the strategic problems of renegotiation. Previously the groups in which the producers compete

[42] See Williamson (1985), Hart (1995), and Milgrom and Roberts (1992) for further analysis of the pros and cons of renegotiation.

[43] Williamson (1985) refers to this as the problem of forgiveness.

according to their relative performance[44], were divided after harvest. This implied that Danisco Foods considered the production results when dividing the groups. Thus, producers with high yields tended to end up in one group and the producers with low yields in another group. This procedure meant that all producers received a payment close to the average. Hence, the incentives almost disappeared. For this reason the contract has been changed so that the group division takes place immediately after sowing (i.e. before there is indication of the yield). The case illustrates that output information before renegotiation is bad, because the incentives are weakened.

The waste material from the production of sugar beet is sold to the producers according to a fixed price determined in the contract. The waste material can be used as a feedstuff in animal production. The contracts state that the trading terms for the waste material shall be renegotiated if new applications for the waste material are found. This ensures an efficient use of the waste material.

2.4.9 Reduce the direct costs of contracting

The direct costs of contracting are the time and money spent on information collection, monitoring, bargaining, and conflict resolution – i.e. the costs of running the contract. It is important to reduce these costs because they do not directly generate a surplus – on the other hand, they are of course extremely important activities as they provide the information required for well-coordinated and well-motivated decisions[45].

The contract design affects the information requirements. Some contracts are very specific about the actions required from the producer, while other contracts leave a wide range of choices to the producer, cf. the discussion of decentralization section 2.4.2. Often changes in the contract shift information requirements from the processor to the producers and vice versa, without actually reducing the information requirement.

It is important that the parties do not spend too much time and money negotiating the contract. One way of reducing the cost of negotiating is to use the same contract for a long period of time, i.e. infrequent negotiation. Similarly, the cost of negotiation can be reduced by the use of standard contracts, so that no producer can negotiate individual contact terms. Another way of reducing the cost of negotiation is to use simple contracts. Simple contracts are also easy for the parties to understand, we exploit this argument in further detail in section 2.4.10. However, simple contracts may also mean less complete contracts, where more questions are left unanswered in the contract.

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[44] See section 2.4.3.

[45] See Milgrom and Roberts (1992), Williamson (1996) and Hansmann (1996) and chapter 3 of this book for detailed analysis of the direct cost of contracting.

The contract should provide for an effective and cheap means of conflict resolution of issues not specified in the contract. One cheap means of conflict resolution is to use a neutral third person, i.e. an arbitrator. Another solution is to delegate authority to one of the parties in the contract (e.g. the processor), so that he can make the decisions in situations not specified in the contract. However, this requires that the other party trusts that the authority will not be abused. Williamson (1996) describes two ways of creating such trust:

- Reputation: if a processor has a reputation for treating the producers fairly, the risk of losing this reputation may prevent the processor from misusing the authority.
- Long-term relationship: if the parties contract over multiple periods, the risk of losing profitable trade in future periods may prevent the processor from abusing the authority.

Examples

In the contracts for the production of special pigs, the bonuses paid to the special producers are determined in two different ways.

The first way is to pay the special producers a fixed bonus independent of the actual demand for the special pig in question. This approach is used for UK, Italian and EU heavyweight pigs.

The second type of bonus is the market-determined bonus. The market-determined bonus depends on how large a share of the production of special pigs are actually sold as special pigs (and not just as standard pigs). This approach is used for special pigs under the National Special Label (NSL).

Previously, the slaughterhouse determined the total production of NSL pigs through quantity contracts and they paid the producers a fixed bonus. The information requirement is lower for the slaughterhouse with the market-determined bonuses, since the producers automatically adjust their production according to the price signal. However, the information requirement is higher for the producers with the market-determined bonuses. The reason is that a producer must be able to predict the market-determined bonus and therefore the supply and demand on special pigs, if he is to choose the right level of production. Thus, while introducing market-determined bonuses reduces the information requirement for the slaughterhouse, it is questionable whether the total information requirement is reduced, because shifting the information requirement does not solve the information problem.

Most of the contracts, we have studied, involve some monitoring of the producer. However, the degree of monitoring varies from contract to contract. In some of the contracts (e.g. for the production of grass and clover seed and the production of fruit and berries) the monitoring is combined with advice. In such cases it may be more appropriate to consider the monitoring as a two-way communication between the producer and the processor, rather than strictly monitoring.

The contracts in our study point to different practical ways of reducing the cost of contract negotiation. One solution is to avoid individual terms in the contracts. Most of the contracts are offered to the producers on a take-it-or-leave-it basis. I.e. the producers cannot negotiate individual terms[46]. One exception is the contract production of broilers for Rose Poultry, where the growers receive different negotiable bonuses, e.g. bonuses for new buildings and contract bonuses[47]. Another solution is to negotiate infrequently. The grass and clover industry uses the same contract for several years and so limits the number of negotiations.

The contracts also point to different means of conflict resolution. One approach is to use an arbitrator. All contracts in our study specify how one party can require a conflict to be solved by an arbitration institution. Another approach is to delegate authority to the processor, so the processor can determine most of the questions on which the contract is silent. For this to work, the producers must trust the processor. This trust is created in different ways. Firstly, the reputation of the processor plays an important role. In the contract production of peas and sugar beet, the producer associations play an active role in conflict resolution. Hence, the reputation of a processor will be damaged severely if one producer is treated unfairly. Secondly, most of the contracts are based on a long-term relationship[48]. Thus, the threat of losing profitable trade in the future prevents the processor from abusing his authority.

2.4.10 Use transparent contracts

The contracts must for take account for the parties' bounded rationality[49]. The parties act according to perceived incentives, which may differ from the actual incentives. Therefore it is important to use simple contracts, so that the parties can easily relate their choice of action to the compensation scheme set out in the contract.

When designing the contract, it is important to limit the cost of information processing, cf. section 2.4.9. It is also important to remember the cost of studying and understanding the contract. Simple contracts reduce these costs. It can be costly for the producers to translate incentives based on outputs into incentives for optimal inputs. For instance, it may be difficult for a producer to see how the incentives for quantity and meat percentage for pigs should affect their choice of feed.

In order to affect the behavior of the parties the incentives should be articulated ex ante. There is no motivational effect from an unexpected bonus.

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[46] However, some details may be negotiable for the individual producer, e.g. the terms for delivery of grass and clover seed.
[47] The Competition Council (2000) and Rose Poultry (2000).
[48] Most of the contracts are one-year contracts, however the contracts are usually renewed.
[49] See Hart (1995) for a discussion of bounded rationality and the implications for contract design.

Examples
The contracts for the production of peas and sugar beet, respectively, are negotiated between a producers' association and the processors. The producers' association's acceptance of the contract works as a stamp of approval for the contract. This means that the individual producer does not have to understand the contract in detail, because he trusts that his representatives in the producers' association will only have accepted a fair contract. Thus, producers' associations can reduce the costs of studying and understanding contracts.

Consulting may help the producers to understand how the incentives in the contract should affect their production decisions. Most of the processors provide advice to their producers. This reduces the cost of transferring incentives into specific production decisions.

In the contract production of peas, the marginal payment for peas depends on the group size[50]. If a producer increases his production, he also increases the average production in his group and thereby reduces the unit price of peas in his group. The effect is largest in small groups. In chapter 4 we show that the marginal payment for peas varies from around DKr 0.50 to 1.00 per kg. A producer cannot calculate his marginal payment for peas, because he does not know which group he belongs to. Hence, a producer does not know his actual incentives. This reduces the motivational effect of payments.

The producers of potatoes for AKV Langholt do not know the trading terms for quantities above their contracted quantity. This uncertainty about incentives may lead to wrong production decisions, if some producers expect different trading terms than those offered by AKV Langholt after the potatoes have been harvested.

2.5 Conclusion

This paper combines contract theory with experience from actual contracts. Based on the study of contract theory and an examination of eight different contracts between producers and processors in Danish agriculture, we have developed a checklist for contract design. The checklist contains ten rules of thumb for contract design. These rules cover what we consider to be the most important problems for agricultural contracts between producers and processors.

In the project underlying this paper, we have worked with both the practice and the theory of contracting. We close by pointing at some of the implications for the future of applied and theoretical work on contracts that can be derived form this combination.

Consider first the practice of contracting. We have observed that actual contracts can be just as advanced as recent progress in the contract theory. From this perspective, the primary role of research is to understand and rationalize existing

[50] Cf. section 2.4.3.

practice. Also, we have observed that there are considerable variations in the ingenuity of the contracts. In particular, it seems that contracts undergo numerous improvements over time. New contracts are often rather naive and do not take account of some very important problems. Lastly, we have observed that practitioners often design contracts without using contract theory. Instead, the design of a contract is based on experience and a process of trial-and-error. This has advantages, but it is often an unsystematic, costly and uncertain approach that can be improved by more interaction with theory. Based on these observations, we conclude that a theory-based approach to reality and systematic dissemination of information between different agricultural sectors can be a valuable supplement to the existing practice.

Consider next the theory of contracting. Despite recent advances in contract theories, we believe that they are still insufficient and that attempts to apply them in practice reveal several aspects that require further development. The theories stress motivation and develop advanced tools to cope with dishonesty (cheating and lying). Unfortunately, coordination aspects ensuring that the right people are doing the right things at the right time and place are largely ignored. In practice, coordination is just as important and a more balanced theory offering a combination of motivations and coordination tools would be much more valuable. We suggest to analyze contracts from a holistic perspective where the multiple effects are considered and where the trade-offs are made explicitly rather than implicitly. In our view, the structural characteristics and institutional arrangements are more important than the fine-tuning of contracts within a given regime. A holistic and systematic meta-perspective may support such general structural design questions.

CHAPTER 3.

Contract Theory: A Holistic Approach

Abstract

In this chapter we develop a holistic framework for the analysis of contracts. We address different aspects of contract theory and arrange the aspects in a goal hierarchy. The goal hierarchy is developed around the three main aspects of contract theory: coordination, motivation and transaction costs.

3.1 Introduction

This chapter gives a general outline of contract theory. The aim is to provide a theoretical background for the analysis of specific contracts between producers (agents) and processors (principals) in agriculture. This goal determines not only our terminology but also our approach. In this chapter we take a broad holistic approach in an attempt to cover the multiple effects of a contract rather than perform a narrow in-depth analysis of one effect.

Contract theory is based on the assumption of *rationality*. Individuals are depicted as choosing the best means to pursue their goals given the information they have available. Under a perfect rationality assumption, the possible states of nature can be foreseen[1]. A contract can provide solutions for every situation, and there is no need for re-negotiations as time goes by. Under a bounded rationality assumption, an individual cannot foresee all possible states of nature. Contracts therefore will be incomplete, i.e. they cannot specify the actions for all possible contingencies, and re-negotiation will be needed. Whether perfect or bounded rationality is invoked, we generally presume that individuals have unlimited analytical capacity. A bounded rational individual chooses the best decision making procedure and behavior in view of the information available – but since something can have been overlooked, the bounded rational does not necessarily make the objectively (substantially) rational choice.

Contract theory is based also on the assumption of *opportunism*. Individuals are depicted as being selfish and are assumed to exploit the situation they face for their own benefit. An individual will honor an agreement only if it is beneficial for him.

[1] See Hart (1995) for a discussion of rationality assumptions in the contract theory.

Otherwise, he will seek to improve his position by withholding information, by lying or by not acting according to the agreement[2].

There are several advantages of assuming rationality and opportunism. First of all, these assumptions have descriptive power. In reality, rational and opportunistic behavior is in fact part of the picture in many cases. Secondly, from a normative perspective, we may want to impose rational and opportunistic behavior as part of the solution we are looking for. Thirdly, assuming rationality and opportunism places contract theory as an integral part of modern neo-classical microeconomics. Contract theory is thus knitted up with other economic disciplines by relying on the same set of assumptions. Moreover, the assumptions discipline the researcher, who must seek explanations within the confines of rational choice models and who cannot explain new phenomena by suggesting new theories.

Despite its many advances during the last 30 years contract theory does not provide sufficient guidance for *practical contract design*. When designing a contract, a number of aspects must be considered. Analysis of a specific contract is therefore a complex matter. Papers in contract theory as well as papers analyzing specific contracts tend to focus on a single or a few problems within a contracting context. This research approach may be useful in contributing to our understanding of the forces that affect a given situation. But it is not a fruitful approach to practical contract design. The risk in focusing on a single or a few problems is that while coping with problems in one area, new problems may emerge in other areas. In this chapter, we therefore emphasize the *systems view* of contracts. We view contract design as a multi-criteria decision problem and seek compromises that fulfill a number of possibly conflicting goals. By following this approach, sub-optimal solutions can be avoided.

To operationalize the holistic systems view, we propose to use a *goal hierarchy* for contact design. The idea of the goal hierarchy is to define a number of goals, which a contract should satisfy. These goals are then divided further into sub-goals which are again divided etc. The hierarchy must be constructed so that every new level gives a complete description of the goals in the level above[3].

Figure 3.1.1 illustrates the goal-hierarchy we have used in the analysis of specific contracts, cf. chapter 4 and 5. It is based on many of the partial findings in contract theory as well as on a general view of economic mechanisms as means of solving coordination and motivation problems at the least possible transaction costs. In the rest of this chapter we explain the main concerns and principal tools.

[2] These assumptions are described in further detail in Williamson (1985)

[3] This method is described in Bogetoft and Pruzan (1997).

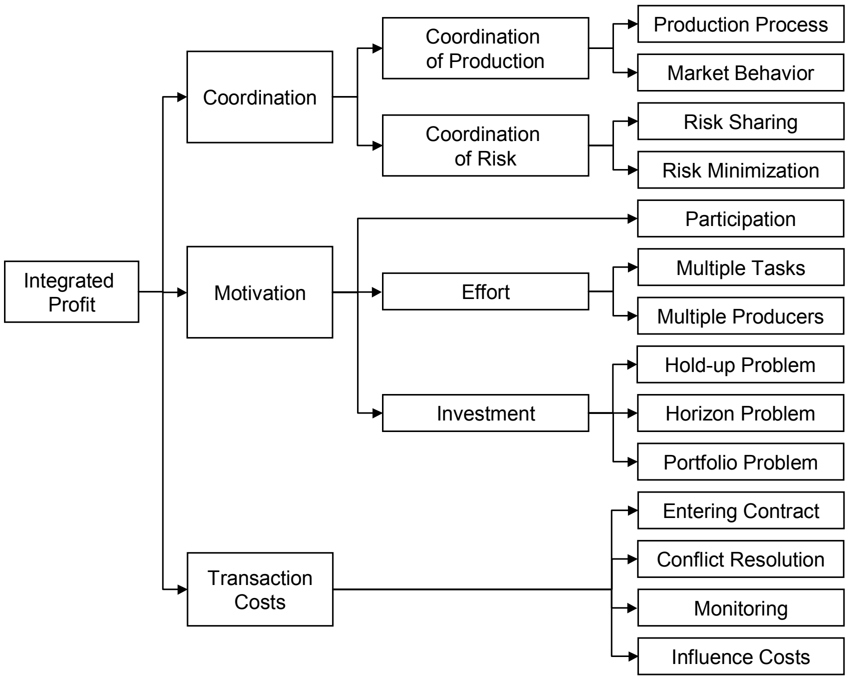

Figure 3.1.1 Hierarchy of goals for contract design

3.2 The Overall Goal

The motivation for signing a contract depends on the preferences of the parties. From an economic point of view, however, it makes sense to claim that the main goal is to maximize the integrated profit, i.e. the sum of the profits of all the contracting parties, the processor and the producers. With a larger total profit, everyone can become better off provided that it is possible to redistribute profit without adversely affecting the behavior of the contracting parties. Contracts resulting in the maximal integrated profit are called *first best* contracts. Alternatively one can talk about the contracts being Pareto efficient in the sense that no one can become better off without someone else becoming worse off.

The Coase Theorem suggests that if property rights are well-defined, independent parties will reach an efficient agreement through bargaining[4].

[4] Cf. Coase (1960).

3.3 Three Main Objectives

Every contract must serve two fundamental purposes. The contract must *coordinate* the production to make sure that the right producers are producing the right quantity of the right products at the right time and place. Also, the contract must *motivate* the parties, giving them private interest in making the coordinated decisions that maximize the integrated profit. The coordination and motivation aspects will often conflict. A solution achieving the best possible coordinating while respecting the potential motivation problems is usually called a *second best solution*. A common conflict between coordination and motivation is derived from the dual role of prices. In many economic mechanisms, prices both send coordination signals and affect the allocation of the gains from contracting. The parties may therefore have individual distributive interest in manipulating the prices even though they have common interests in using the prices to coordinate actions.

An efficient contract contributes to optimizing the coordination and motivation in the cheapest way possible. In other words, it minimizes the costs of planning, monitoring and motivating production, i.e. the *transaction costs.* Transaction costs can be defined in a narrow or in a broad sense[5]. Narrowly conceived, the term refers to the costs of making, monitoring and enforcing contracts but more broadly transaction costs can be thought of as including any kind of barrier to efficient, decentralized exchange. We will use the narrow definition in our work. The indirect costs of the organization slowing down are included in the relevant parts of the first two main goals, coordination and motivation. Hence, this presentation invokes the assumption that production costs and transaction costs are separable. This is a common assumption in transaction cost theory[6].

3.4 Coordination

To maximize the integrated profit, the behavior of the parties must be coordinated, such that the right goods are produced in the required quality and quantity at the right time and place. On aspect of this is ensuring that production and processing costs are minimized. Another is ensuring that the costs of risk are minimized. This requires that the total risk is minimized and that the existing risk is borne in the cheapest possible way, i.e. primarily by parties with low risk-aversion.

3.4.1 Coordination of production

There are two fundamentally different approaches to the coordination of production. One approach is *hierarchical planning* where a central decision-maker determines the actions of each producer and coordinates behavior via instructions. The other

[5] Deakin and Jonathan (1997).
[6] This distinction is discussed in Coase (1937) and Milgrom and Roberts (1992).

approach is the *market approach* where the production is determined by the invisible hand of the market and coordinated via price-signals[7].

Often contracts use both of these coordination mechanisms simultaneously. Certain aspects are controlled by a price mechanism while others are controlled by central decision-making. General production levels are often delegated to the individual producers and coordinated by a price signaling the demand-conditions. For some crops, the harvesting, transportation and processing must be synchronized precisely. Otherwise the products are ruined because they perish before they can be processed. Harvesting of peas by Danisco Foods is an example of this, cf. chapter 4. For synchronization and matching problems, price signals alone are usually insufficient as means of coordination. Instead the coordination is achieved through central decision-making where the processor determines the time of harvest or the product specifications for each individual producer.

To determine a suitably coordinated production plan, there is a need for *information*. Information on the revenue and cost functions of the processor and information on the producers' costs functions. No single decision-maker holds all this information ex ante. Typically, the information is distributed such that the parties have private information about their own cost and revenue functions. Moreover, the opportunistic behavior implies that they will reveal their private information only if it is in their private interest to do so. The processor may not find it advantageous to reveal the profit on the product, since it indicates what can possibly be shared with the producers. Similarly, the producers may be reluctant to reveal their true production costs because it could improve the bargaining position of the processor. Thus, hierarchical coordination of production requires incentive schemes to motivate truthful revelation of information to a central decision-maker (planner). Alternatively one may rely on decentralized decision-making and construct incentive schemes that induce each party to exploit their private information to make decisions that maximize the integrated profit.

[7] Since this lies in the heart of much economic theory, there is a substantial literature dealing with coordination using prices and restrictions. The virtues of prices are often emphasized by referring to the first and second welfare theorem from microeconomics. They demonstrate how a perfect price mechanism leads to Pareto optima and how any Pareto optima can be supported by price-mechanisms, cf. e.g. Gravelle and Rees (1992). From a planning perspective, there is a considerable literature on how a decentralized organization can operate. One stream of formal literature is the so-called team theory, cf. Marschak and Radner (1972) and McGuire and Radner (1972). A team is a group of people who agree on an overall goal and who collaborate in solving a common problem in such a way that each member has some private action and some private information. Important issues now become how to design the individuals' decision areas, how to design partial goals for individuals to pursue so as to contribute to the overall goal, and how to design a not too costly communication structure. Another line of literature treats iterative and multi-level planning procedures, cf. e.g. Bogetoft and Pruzan (1997), Dirickx and Jennergren (1979), Johansen (1977,88), Meijboom (1987), and Obel (1981). The subject of this literature has been the coordination problem in a divisionalized firm or a planned economy. This line of research has been concerned with the design of procedures that exhibit certain desirable properties like convergence, feasibility, monotonicity, and efficient use of information.

A well-known coordination problem concerns the choice of production levels at different stages of the supply chain. If the different stages operate separately and choose their production levels independently to maximize their own profit, the *double marginalization* problem can arise[8]. Each stage of the production chain exploits its marked power by reducing the quantity it supplies to raise its price. This will cause a two-fold reduction in supply, which in turn will reduce the integrated profit. The double marginalization problem is caused by the fact that the processor does not choose the quantity based on the producers' production costs but rather based on the prices he pays the producers. If the producers have market power, these prices will be above the production costs. The standard solution to the problem is a contract in two parts, one providing a transfer price equal to the marginal production cost and another providing an additional fixed transfer.

In determining the supply it is important to consider how the *competition* in the market is affected. In some cases, a large supply will trigger an aggressive response from competitors. In other cases, a large supply can force competitors out of the market or prevent new competitors from entering the market. The large market shares of cooperatives may be caused by their use of transfer prices (between the cooperative and the producers) equal to average revenues. Although the average revenue payment scheme leads to over-production in a monopolist cooperative, it may be attractive in an oligopolistic setting where it may induce other competitors to operate at lower levels[9].

The way in which the food production is organized can influence the possibilities of new firms of entering the market. A processor can create *barriers to entrance* for potential competitors by using long-term contracts. One explanation of the few foreign actors in the Danish food industry may be that the cooperative tradition in Denmark has created very close links between processors and producers[10].

3.4.2 Coordination of risk

Since most economic parties are risk averse, the existence of risk is costly. A measure of the costs is the risk premium, which is the difference between the expected payment and the certainty equivalence giving the agent the same utility[11].

There are two aspects of minimizing the cost of risk in a contractual relationship. First, the risk should be shared in a way that makes the total cost of risk

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[8] Tirole (1988) analyses this problem.

[9] Cf. Albæk and Schultz (1998)

[10] Cf. Hansen (1997).

[11] Formally, we have: $RP(s,U) = E(s) - CE(s,U)$, where *RP(s,U)* is the risk premium of a risky payment *s* for an individual with utility function *U*, *E(s)* is the expected value of the risky payment *s* and *CE(s,U)* is the certainty equivalence, i.e. the certain payment making the individual with utility *U* equally well off as he is with the risky payment s.

bearing as low as possible. Second, the contract should minimize the total risk. The following sections deal with these problems.

Risk sharing

Risk sharing is an important topic in contract design because it affects both the costs of risk-bearing (the risk premium) and the motivation to behave in certain ways (the incentives). The optimal arrangement therefore involves a *trade-off* between the *efficient (cost-minimizing) risk sharing* and the *provision of incentives*. This trade-off is described in further details below.

It is often assumed that large firms are less risk averse than (family) farmers[12]. Several circumstances may contribute to this. The owners of large firms can often diversify their investments on the stock market (i.e. buy stocks in other firms as well). The producers on the other hand often have a high debt ratio and they therefore have limited opportunities for diversifying investments. Typically the producers do obtain a certain diversification by producing more than one product, e.g. pigs and wheat.

From a pure risk sharing perspective, the processors therefore should bear more risk than the producers. In particular, if the producers are risk averse and the processor is risk neutral, the processor should bear all risks and the producers should receive constant payments. However, this will generate motivational problems. A producer who receives a constant payment can reduce his effort without consequences. Hence, a constant payment provides no effort incentives. For this reason the risk sharing arrangement must take into account the conflict between efficient risk sharing and motivation[13].

Agricultural production is exposed to several sources of risk. It is not necessary to impose the producers to every type of risk in order to ensure motivation.

Often, the producers are affected by *general risk*, e.g. weather conditions. Eliminating the general risk from the payment to the producers improves the risk sharing without adversely affecting the incentives. Specific means of filtering away the general risk from the payment to the producers are yardstick competition or, in general, relative performance evaluation[14]. Removing the general production risk from the payment to producers sometimes has other disadvantages. They will be discussed later.

Agricultural production is subject to *price risk* from variations in prices on in- and outputs. Variations in prices give no information about the effort of an individual producer. The theory therefore suggests that the price risk should be borne

[12] See e.g. Hansmann (1996), Knoeber (1989), Knoeber and Thurman (1995), Tsoulouhas and Vukina (1999).

[13] This trade-off is dealt with in more detail in section 3.5.2.

[14] Holmström (1979,82) initiated fundamental work on relative performance evaluations. The use of yardstick competition in case of simple production structures is discussed in Shleifer (1985) and extensions to more complicated production models are provided in Bogetoft (1997).

primarily by the least risk adverse party, i.e. the processor. This speaks in favor of production contracts with constant prices. However, price changes can affect the desired level of effort. This supports the use of variable prices, e.g. market prices, in production contracts to encourage demand adaptation, e.g. increases in production when output prices are high, and vice versa.

The *idiosyncratic production risk*, i.e. the risk that cannot be ascribed to general production conditions, give indirect information about the effort of the producer. Therefore, this type of risk should be distributed to balance the risk-sharing objective against the motivational objective.

Minimizing risk

The contract design can influence the level of risk in several ways.

If the contract does not allow for adjustments to changes in production and market conditions, the total risk in the producer-processor relationship can increase. A *non-adjustable* contract may prevent the parties from makinge mutually attractive adjustments in the production and marketing plans.

Also, long-term contracts using *fixed product prices* can generate risk. A fixed product price ensures the producers against variations in the market price of the processed product. However, if the inflation and the production costs vary, it may actually increase the risk to freeze the sales prices. What matters to a producer is his total risk and this may actually increase by freezing the income while letting the cost components vary. The natural "portfolio"-insurance created by negatively correlated income elements is lost by naively providing insurance against some components and not against others. One way to solve this problem is to avoid long-term contracts. This, however, may cause behavioral uncertainty, which we discuss in section 3.5.3. Another possible solution is to agree that producer prices will follow a certain price index. This practice is for example used in Danish tenant contracts where the land rent varies with the barley price[15].

Another way to minimize the total risk is to distribute risk according to the *effects of bankruptcy*. Bankruptcies involve considerable costs, including both the cost of the bankruptcy procedure itself and the potential costs arising from inefficient use of the assets after the bankruptcy. For example, a bankruptcy can lead to the liquidation of a firm which could have been profitably reconstructed. High costs of inefficient use of assets after a bankruptcy are particularly widespread in cases of asymmetric information due to inefficient negotiation[16]. In addition to the losses incurred by owners and creditors in the case of bankruptcy, other parties might lose as well. If a producer goes bankrupt, the processor will lose a supplier. Even if the producer can be replaced, it is costly to do so. A new contract must be signed; the new producer must be introduced to the specific production techniques, etc. Still, the

[15] See for example; De danske Landboforeninger (Farmers Union) (1990).

[16] For a further description of these costs, see Hart (1995) and Milgrom and Roberts (1990).

processor's loss in such cases is likely to be modest. The bankruptcy of a processor can have more widespread implications. If the processor goes bankrupt, the producers may suffer severe losses as they lose their marketing channel.

The owners and the creditors of an investor-owned processor have no private incentives to take into account the losses incurred by the producers if it is decided to liquidate the processing firm. Hence there is a risk that a processing firm will be liquidated even though, from the point of view of maximizing the integrated profit, it would be more profitable to reconstruct it. In such cases the producers should, according to the Coase theorem, offer compensation to the owners and creditors in order to make it optimal for them to reconstruct the firm. In reality, however, it is very difficult for the producers to compensate the owners and creditors for not liquidating the processing firm. One problem is free riding, where some producers do not contribute to the compensation – but benefit from avoiding the bankruptcy. Another problem is the asymmetric information in the negotiation process. The owners and creditors do not know the producers' true willingness to pay and (opportunistic) lying may be privately advantageous. Asymmetric information can therefore lead to an inefficient bargaining outcome. Thus, there is considerable risk that the producers will lose in the case of bankruptcy negotiations. As a consequence, placing a large part of the risk on the producers may actually reduce the total risk in the production chain – however measured.

We close by pointing to yet another consideration that may make it optimal to place most of the risk on the producers even though the processor is less risk-averse. It is natural to assume that the producers will not accept a contract that the processing firm is unable to fulfill. This gives an upper limit to the processor's risk bearing capacity; namely the sales value of the firm in case of bankruptcy[17], which in turn suggest that more risk should be allocated to the producers.

3.5 Motivation

Contract theory assumes that people act opportunistic. Consequently, they will only act as planned and reveal private information if it is in their interest to do so. This necessitates motivation. Motivation is required to align the interests of the independent decision-makers, i.e. give each decision-maker a private interest in making decisions that will maximize the integrated profit.

Motivation and incentives has been the primary focus in modern contract theory as exemplified by the last 30 years of advances in the principal-agent literature. We have chosen to emphasize also the more traditional coordination aspects above, since we believe that they are just as important and somewhat ignored in the contract literature.

[17] This argument is suggested in Tsoulouhas and Vukina (1999).

3.5.1 Participation

The contract must make the parties willing to participate. To do so, the contract must provide all parties with utilities (profits) at least equal to what they could obtain outside the contract, i.e. their reservation utilities or reservation values. These constraints are often referred to as *individual rationality* (IR) constraints.

The selection of contract producers leads to different participation problems. If the producers have private information[18] about their type, e.g. their production costs, their reservation utilities or their skills, an *adverse selection* problem arises when the processor tries to select the most appropriate producers. If the processor offers a payment equivalent to the average reservation utility of the producers, the contract will attract only those producers with reservation utilities below this average. This results in an overcompensation of the producers entering the contract. In literature this overcompensation is referred to as information rent. If the processor holds information about the characteristics of the producers, he may still be prevented from *discriminating* among them in the contract. The reasons can range from legal restrictions and bargaining power of the producers to fairness, transaction costs, etc. In a situation like this the processor has to offer all producers the same contract. The result is that producers with low costs (or low earning possibilities outside the contract) are offered the same payment as producers with high costs. The low-cost producers thus acquire an information rent.

The processor can reduce the problems related to selection of producers in several ways. One option is to lower the payment so that only a small fraction of the producers choose to participate in the contract. This *rationing* approach gives the processor fewer but better deals (contracts), since it is no longer necessary to make high cost producers participate.

Another possibility is to *condition the payment* on a signal that is related to the producer's type (e.g. his reservation utility). In many agricultural contracts this is accomplished by letting the payment depend on the level of output. This method ensures a high payment to producers with large output potentials, who typically have the highest reservation utility.

A final possibility is that the processor offers a *menu of contracts*, each aimed at a certain group of producers. The processor can design the contracts in a way so that the different producers self-select the contract which the processor prefers them to use[19]. A simple example of a menu of two contracts is the contracts below, both giving the same payment to an average yield:

- Payment depend on output (high yield, high payment)

[18] Private information can consist in either hidden actions or hidden information. If private information exists prior to entering the contract, this will lead to *adverse selection*. Private information appearing after the contract has been entered lead to *moral hazard*. This concept will be dealt with later in this chapter.

[19] In literature this is known as *self-selection* or *screening*; see e.g. Salanié (1997).

- Payment is constant (independent of yield)

The first contract attracts producers expecting a high yield and thus a high payment. The second contract is attractive to those producers who expect a low yield.

If the processor is restricted to use only one contract for all producers it will still, in some cases, be possible to differentiate the payment to the producers. First of all, it is possible to use payment based on outcome, cf. above. Secondly, the processor can use *relative performance evaluation*[20]. Relative performance evaluation is often used in combination with the division of producers into groups in which the producers compete internally. If the processor has the authority to determine the group division, he can use this instrument to reduce the producers' information rent[21].

3.5.2 Effort

The contract must take into account that the processor and the producers are independent decision-makers looking out for their own interests. To implement a production plan the producers must have a personal interest in following the plan. This leads to the *incentive compatibility* (IC) constraints. The requirement is that each producer maximizes his own utility by sticking to the choices in the coordinated production plan[22].

To ensure incentive compatibility, the parties can rely on monitoring systems and reward and penalty mechanisms.

Monitoring can be based on either input (effort) or output. If the input is monitored, the reward or penalty can be linked directly to the factor the parties are trying to regulate via the contract. However, in many contexts, it is not possible for the processor to monitor the producers' inputs[23]. Instead, the payment must be conditioned on the resulting level of output. By the biological nature of farm production, the output is inherently uncertain. This inevitably leads to uncertainty in the evaluation of the producers' efforts. The optimal intensity of the incentives depends in this case on the amount of uncertainty involved in the input-output relationship; cf. section 3.4.2.

Penalty or reward mechanisms can also be used to motivate the producers. One possibility is to use variable payments, increasing the payment when the processor

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[20] Cf. appendix 3.8.3.

[21] Part 3 of this thesis demonstrates how a processor can reduce the producers' information rents through strategic group division in relative performance evaluation contracts.

[22] Formally, an action a^* from a set of possible actions A, is incentive compatible if:

$$a^* \in \arg\max_{a \in A} \left[U_i(a) \right]$$

where $U_i(a)$ is the expected utility to producer *i* from the action *t*.

[23] In literature, this is described as *hidden actions* on the side of the producer, creating the motivation problem called *moral hazard*.

receives positive signals about the producer's effort. Another penalty-reward mechanism is to either terminate or extend the contract depending on the signal received. This latter approach is effective if the contract ensures the producer a utility above his reservation utility, cf. section 3.5.1.

The informativeness principle

It is usually impossible for the principal observe all aspects of the producers' input. Hence, the payment must be based on imperfect signals. For instance, many payment schemes are based on the producer's yield, which depends on both effort and non-controllable environmental factors. In the section on risk sharing we mentioned the trade-off between risk sharing and motivation. In order to minimize the cost of risks while maintaining effort incentives, it is crucial to choose signals that are strongly correlated with the actual effort of the producer.

One way to reduce the uncertainty is to use more parameters to determine the payment. In theory, one should rely on all indicators that can reduce the uncertainty about the producer's effort[24]. Such indicators might include the average yield for all producers of the year, the soil quality, etc. This result is called the *informativeness principle*. In the section on transaction cost (section 3.6) the informativeness principle is discussed in relation to transaction costs.

Sometimes the processor has subjective information about the producer's effort. Subjective information is hard to include directly in a contract, since it is non-verifiable. The processor may therefore have incentives to manipulate the information in order to reduce the compensation he has to pay. *Subjective, non-verifiable information* can nevertheless be used in contracts if the processor can commit to a certain average payment. This eliminates the processor's incentives to distort the non-verifiable information, since only the allocation of payment among producers, and not the total payment, depends on the non-verifiable information[25].

Incentive intensity

Four factors make it attractive to increase the *incentive intensity*, i.e. the degree to which payment depends on performance[26]:

1. The incremental profit to the processor created by additional producer effort
2. The risk tolerance of the producer
3. The precision by which the desired activities are assessed
4. The producer's responsiveness to incentives

There is no reason to give incentives to increased effort if higher effort does not generate higher profit. On the other hand, it is appropriate to motivate high effort

[24] See Holmström (1979) for a formal analysis of the problem.
[25] Bogetoft (1994) demonstrates this.
[26] This is based on a model by Holmström (1979). Appendix 3.8.1 gives a more formal outline of the model.

when the effort has a significant impact on the profit. Therefore the incentives should be stronger, the larger the *incremental profit* to the processor.

The more risk averse the producer is, the larger is the cost of exposing him to risk. This explains why incentives should be stronger, the more *risk tolerant* the producer is.

The third factor is the *precision* by which the producer's effort can be inferred. The argument here is that increased precision reduces the uncertainty in the inference process and thus reduces the risk premium. If the processor gets very precise signals about the producer's performance, a more high-powered incentive scheme can be used without imposing too much risk on the producer.

Finally, the choice of incentive intensity should depend on the producer's *responsiveness* to incentives. If the producer is unable to respond to the incentives, more high-powered incentives will only expose him to more risk. Consequently, the incentives can be stronger the more the producer can respond to them.

An extreme version of the intensity principles deals with cases where it is possible to observe the effort without noise. In such cases, there is no real motivation problem. A threat of an extremely severe penalty if a deviation from the agreed effort is observed is sufficient to keep the producer from deviating. This threat has no cost and will never be carried out in equilibrium, since it will deter deviations and will never hit an innocent producer. In fact, when the effort can be observed without uncertainty, it is sufficient to perform only random controls if the penalty is sufficiently harsh. This phenomenon is known as *moving support*[27]. A practical difficulty with a moving support scheme is of course that limited liability may prevent the use of very harsh penalties. Often the producers have limited financial reserves. Planning a harsh response to deviations may therefore turn out to be nothing but an empty threat.

Multi-tasking

When the producer performs multiple tasks, the incentives must be *balanced.* Otherwise the producer might focus too much on one task at the expense of the other tasks. The tasks can be to produce different products or to produce different characteristics of a given product, e.g. quantity, taste, and animal welfare.

An opportunistic producer will adjust his efforts towards the different tasks so that the marginal revenue equals the marginal cost. If his efforts towards the different tasks consist of time spent, he will distribute his time such that his marginal revenue is the same for all activities. As a result, activities with lower marginal revenue than others will not be carried out.

Very often the different tasks can be monitored with different levels of precision. This may tempt the processor to use high-powered incentives for tasks with a high measuring precision, as this will not impose excessive risk on the producer.

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[27] See e.g. Salanié (1997).

However, placing strong incentives on tasks that are easily measured and weak incentives on other tasks can easily result in the producer focusing on the measurable tasks at the expense of the other tasks. For instance, the producer might concentrate on supplying quantity and focus less on quality. Because of this, one needs to be very careful in providing balanced incentives whenever the producer is solving multiple tasks[28]. In appendix 3.8.2, we formalize the "*equal compensation principle*".

Multiple producers

If several producers perform similar tasks, it is possible to use relative performance evaluation. This instrument enables the processor to obtain information about the common risk affecting all producers.

Contract theory distinguishes between relative and absolute performance evaluation. In *relative performance evaluation* the payment to a producer depends on how good his results are relative to other producers. In contrast, the standards used in *absolute performance evaluation* are determined before the production is carried out.

One advantage of using relative instead of absolute performance evaluation is that it becomes possible to eliminate uncertainty concerning exogenous factors. Often in agricultural production, exogenous factors like weather conditions will affect all producers. If the producers are risk averse and the processor is risk neutral, it is optimal to transfer the general risk to the processor, cf. section 3.4.2. Relative performance evaluation is a means to do so.

Yardstick competition is a simple form of relative performance evaluation. The method is to compare the performance of each producer to the performance of the rest of the producers. A yardstick contract will typically look like this:[29]

$$\textit{Payment} = \textit{base payment} + \textit{bonus factor} \times \textit{deviation from average of other producers}$$

One potential problem of relative performance evaluation is that the producers may agree to reduce their effort and then subsequently explain the poor result as being a consequence of general production risk. This problem is known as *collusion*. In relation to agricultural production the problem of collusion is probably limited as the large number of producers typically makes it difficult to sustain a producer cartel[30].

[28] The problem has, among others, been analyzed in Holmström and Milgrom (1991).

[29] Shleifer (1985) compared the performance of one producer with the average performance of the other producers. Bogetoft (1994, 95, 97 and 2000) demonstrated that comparison of one producer with the best practice of the other producers may be optimal in cases with complicated, multiple dimensional production structures.

[30] Moreover, several (costless) modifications has been developed to destroy such collusive behavior, including the use of "processors pet", i.e. a producer that flags on the other producers if a collusion is planned, cf. e.g. Bogetoft (1995) or more fundamentally Ma, Moore, and Turnbull (1988).

Robustness

Robustness concerns the ability of a contract to work well under changing conditions. This is an important property when one considers the costs of redesigning a contract. A robust payment scheme will give reasonable incentives in both good and bad years.

Linear contracts are often believed to be particularly robust[31]. Linear contracts are of the form

$$\textit{Payment} = \textit{base payment} + \textit{piece rate} \times \textit{outcome}$$

The advantage of using linear contracts is, among other things, that the incentives are equally strong regardless of outcome level.

3.5.3 Investment

To ensure future profits, it is important that a contract gives the parties appropriate incentives to invest. To do so, the contract must deal with several issues, including the hold-up problem, the horizon problem and the portfolio problem.

The *hold-up problem*[32] arises if a producer's investment has higher value in dealing with a specific processor than in alternative relationships. When the production or the investment is completed, the processor is able to exploit its exceptional status and demand a large portion of the profit gains from future cooperation. In this way, the producer may end up paying the full cost of the production or investment without receiving all the benefits. Fear of this can lead to under-production or under-investment.

Both the producer and the processor can hold up the other party. The processor can hold up the producers by lowering the payment after the producers have made specific investments, or the producers can exploit specific investments made by the processor, and hold up the processor by demanding a higher payment. However, in agricultural production the producers often lack a strong producer organization. This reduces the risk of the producers holding up the processor.

The hold-up problem can arise only if the following two conditions are present. First, *specific investments*, i.e. investments with a lower value outside the contractual relation than within, must be involved. Williamson, who developed much of the basic theory on hold-up, mentions the following types of specific investments[33]:

- *Geographically*, assets useful only in a few trading relations because the costs of transport make it impossible to deal with other parties.
- *Physically*, assets developed to be used exclusively for a certain type of production.

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[31] See for example Milgrom and Roberts (1992).
[32] See e.g. Tirole (1988), Hansmann (1996) or Hart (1995).
[33] See Williamson (1985, 1996).

- *Human*, assets in the form of education, training and experience, which cannot be employed in other types of production.
- *Dedicated assets*, assets designed to meet special requirements with the counterpart.
- *Special brands*, investments in development and marketing of a new brand.

The second condition for hold-up is the use of *incomplete contracts*, i.e. contracts that do not specify how the parties should behave in every possible situation, cf. section 3.1. This condition prevents that every hold-up possibility is ruled out when the contract is entered. Put differently, it is not possible to enter long-term complete contracts before investments are undertaken and thereby solve all possible hold-ups. In real life it is not possible to construct complete, long-term contracts that will never require renegotiations of certain parts of the contract, see also section 3.6 on transaction costs.

If the processor is organized as a producer-owned cooperative, a number of different investment problems arise. One such problem is the *horizon problem*. It stems from the fact that no one has personal ownership of the equity in the cooperative. Because of this, members of a cooperative have no incentive to invest in projects of which the return falls after they have left the cooperative.[34]

Another investment issue in cooperatives is the *portfolio problem*[35]. If the returns on investments at the farms are positively correlated with the returns on investments in the cooperative, the producers will face additional risk as both their farm incomes and their returns on cooperative investments may be simultaneously reduced. To obtain a better diversification of their investment portfolio, the producers may want to avoid investments in the cooperative.

3.6 Transaction Costs

The existence of firms in a free market economy might seem contradictory. Why do we have more or less planning sub-economies within the market? Why do individual agents not just buy and sell labor etc. via the market?[36]

The obvious answer is that alternative mechanisms have different transaction costs or frictions. Firms are the result of the transaction costs from using the market, e.g. the search-costs involved in identifying appropriate trading partners. In this sense transaction costs can be seen as friction in the market. Transaction costs also exist for off-market transactions. It includes costs of motivation and coordination inside a firm or in a contractual relationship.

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[34] Bogetoft and Olesen (2000) analyze the horizon problem.
[35] See e.g. Hansmann (1996) and Bogetoft and Olesen (2000).
[36] In a, by now, classical article, Coase (1937) dealt with this fundamental question.

The hypothesis of transaction costs economics is that transactions are organized to minimize transaction costs. In the following, four types of direct transaction cost are analyzed.

3.6.1 Entering a contract

There are three primary sources of transaction costs when entering a contract[37].

The first one is the difficulty of *foreseeing* the possible contingencies in a complex world, i.e. the difficulty in setting up a complete set of possible outcomes. There are several situations in agriculture that has not been foreseen and worked into contracts. The BSE-crisis is one example of this.

The second source of transaction costs is the cost of *wording* a contract. In order to reach an agreement taking different contingencies into account, the parties have to find a common language describing the different contingencies and the connected actions.

The cost of writing a *legally binding* contract is a third source of transaction costs. It is not sufficient for the parties to agree upon a common wording of the contract. The contract must be written down so that the contract can be understood and be enforced by the judicial system.

There are several ways to reduce the transaction costs of entering a contract. One method is to minimize the number of negotiations. This can be accomplished by using a standard contract with all producers. If the processor negotiates this contract with a producer organization, it is not necessary for each producer to engage in negotiations; this can be left to the committee of the producer organization. This reduces the producers' transaction costs of entering the contract.

Transaction costs will cause the parties to enter *incomplete contracts*, i.e. contracts which do not give specific guidelines for every situation. Incomplete contracts create a need for subsequent negotiations to solve the questions left unsolved in the initial contract. These negotiations can lead to hold-ups, cf. section 3.5.3, as well as to costs of conflict resolution.

3.6.2 Conflict resolution

In practice, contracts are incomplete and situations will arise for which the contract does not provide a solution. Solving conflicts like these gives rise to the same types of transaction costs as does entering the contract. This is why it is important that the contract provides efficient tools to ensure fast and inexpensive conflict resolution.

The cost of conflict resolution can be reduced if the parties have agreed upon a procedure for settling disputes, e.g. the use of an *arbitrator*. Time and money can be saved if the parties use an arbitrator institution and avoid long trials. However, using

[37] A more detailed analysis of the costs of entering a contract are found in Hansmann (1996), Milgrom and Roberts (1990) as well as Milgrom and Roberts (1992).

an arbitrator is a rather complicated procedure, so there is a need for other mechanisms as well.

One of the options is to delegate decision right, authorizing one party to make decisions in situations where the contract is silent. However, this requires that the other party *trusts* that the authority will not be abused. There are two ways to bring about this trust[38].

The first way to create trust is to enter into a *long-term contractual relation*, where the contract is renewed every year. This corresponds to what is known in the literature as repeated games. The advantage of a long-term relation is that it is possible to penalize the party misusing the trust by terminating the partnership.

The second approach is to rely on *reputation.* The idea is that if a processor abuses the trust of a producer in one contractual relation, this will become known and this will damage other relationships that the processor has or will become involved in. An opportunistic processor will therefore be careful not to wreck its reputation by abusing its decision right. An efficient tool to build up trust and reputation is to enter into an agreement with a producer organization. This will restrain the processor from abusing its decision right, since the relation to the producer organization will suffer if just one producer is mistreated. A producer organization can effectively communicate the actions of the processor to the producers, and hereby contribute to the strength of the processor's reputation.

3.6.3 Monitoring

Basically, a processor has two instruments to ensure that the producers supply the right effort. One is the use of incentives as described in section 3.5.2. The other is monitoring. Monitoring creates a number of direct transaction costs. They include wages to inspecting personnel, cost of information systems etc. These costs must be balanced against the benefits of monitoring.

In section 3.5.2 we argued that incentives should be balanced considering the measurement precision. Increasing the measurement precision through monitoring or weakening the incentives will reduce the risk premium to producers. The gain from increased precision is larger the stronger the incentives. Also, if monitoring is increased, it is possible to use stronger incentives without increasing the risk premium. Ideally, the intensity of both incentives and monitoring must be chosen simultaneously.

3.6.4 Influence costs

A fourth type of transaction costs is influence costs[39]. These costs arise when one party tries to increase his utility by influencing the decisions made by another party.

[38] See also Williamson (1996) and Hansmann (1996).
[39] These costs are analysed in detail in Milgrom and Roberts (1990).

Influence costs consist in the time and energy spent on attempts to gain influence rather than to produce. Discussions concerning adjustments of contracts etc. can take up a large share of the management's time, leaving less time for other tasks.

One party in a contract will often try to influence the decisions of the other party by holding back information, by distorting information (lying), by exploiting connections and specific knowledge etc. These activities are unproductive and therefore a source of transaction cost.

Two factors affect the level of influence costs in a contractual relationship: (1) the decisions that influence the other party in the contract relation, and (2) the communication prior to decision-making. By reducing the number of decisions or by reducing the communication one can reduce influence costs. Often a contract will employ both methods.

There will always be a number of decisions affecting another party in the contract. However, there are several ways to *reduce the number of decisions that can be influenced*.

The first method is to limit the contract to only a few parameters, i.e. making it as simple as possible. This may conflict with the informativeness principle according to which all parameters reducing the uncertainty should be included in the contract, cf. section 3.5.2. One must therefore trade-off the risk concerns and the influence costs when determining the number of parameters in the contract.

The second method to limit the number of decisions is to use objective rather than subjective parameters in the contract. Objective measures do not leave room for discussion in the same way subjective assessments do.

It is also possible to reduce the influence costs by appropriate planning of the decision-making process. If a decision-maker has to comply with very strict regulations, there are fewer decisions to influence. Finally, the number of decisions can be reduced through a standardized contract and by infrequent re-negotiations as mentioned in the previous section.

There will always be a need for some communication to establish reasonable decisions, but *limiting communication* is a rather efficient tool to reduce influence activities. Again, a trade-off must be made – now between the value of information as basis for decision-making and the influence costs.

Many cooperatives are reluctant to reveal a detailed break down of revenue numbers. The producers of organic milk in Denmark, for instance, do not know the dairy's revenue from the organic milk[40]. This policy can be seen as an attempt to reduce influence activities by depriving the organic milk producers the information they need to seriously discuss the distribution of surplus.

[40] See Andelsbladet (1997).

3.7 Conclusion

In this chapter, we have given a non-technical introduction to contract theory. We have developed a holistic perspective covering a wide spectrum of concerns. The concerns have been organized in a hierarchy of various aspects to consider when designing a contract between producers and a processor. We have addressed three main objectives leading to the fulfillment of the overall goal: maximizing the integrated profit.

The first main objective is to coordinate the producers actions to ensure that the right products are produced at the right times and places. This requires coordination of the production process. The producers can be coordinated via price signals or through direct instructions – or some combination of both. The contract should also coordinate the risk, such that the total risk is minimized and that the risk is borne in the least expensive way.

The second main objective is to motivate the producers and the processor. It must be in the interest of the individual parties to participate in the contractual agreement and to make decisions that contribute to the maximization of the integrated profit. Furthermore, it is important that the contract does not create hold-up problems, where one party exploits that the other party is lucked-in by specific investments.

The third main objective is to limit the transaction costs, viz. the cost of negotiating and writing the contract, the cost of conflict resolution, the costs of monitoring, and the cost of influence activities. This can be done by, for example, reducing the frequency of renegotiations or by using standardized contracts.

The different concerns will often be conflict. A classical conflict is between motivation and optimal risk sharing. If a risk averse producer is insured via a constant payment he will lack incentives to provide effort.

The best possible contract in a world with imperfect information and conflicting interests is a second best contract. The second best outcome deviates from the ideal first best outcome in several ways. First, it involves *direct contracting costs*. These are the transaction costs spent on planning, writing and administrating contracts. Second, the second best outcome involves *indirect contracting costs*. They show up as *sub-optimal adaptation of production to types* (e.g. when bad types under-produce or are rationed away entirely to save rents to the good types), as *sub-optimal supply of effort* (e.g. because of the costs necessary to compensate for risk in high powered schemes), and as *sub-optimal risk-sharing* (e.g. when risk is imposed on a risk averse producer to motivate his supply of effort).

The numerous concerns covered in this chapter emphasize the complexity of contract design. Therefore we need a systematic theoretical approach. We believe that a decision theoretical approach based on a conceptual multiple criteria perspective provides such a tool. We also need to systematically learn from the trials and errors of many years of contracting practice. The fact sheets on actual contracts in chapter 6 provide a tool for this learning.

3.8 Appendix

3.8.1 Incentive intensity

The following model is due to Holmström and Milgrom (1991). Consider an agent providing the effort *a* and thereby creating the value *B(a)* to the principal. The principal cannot observe *a.* Instead the payment is based on the output, given by $x = a + \varepsilon$, where ε is noise. The payment is given by

$$s = \alpha + \beta x,$$

i.e. a linear contract with a base payment α and a piece rate β. *C(a)* is the cost to the agent. The agent has a utility function $U(x,a) = -e^{-r(x-C(a))}$. The principal is risk neutral, while the agent requires a risk premium of $½r\beta^2V$, where *r* is the agents absolute risk aversion and *V* is the variance of the output. Under these conditions the optimal incentive intensity is given by:

$$\beta = \frac{B'(a)}{1 + rVC''(a)}$$

The model shows that the intensity of incentives should be stronger (i.e. have larger β):

- The higher the marginal revenue to the processor from an increase in producer effort (larger $B'(a)$)
- The less risk averse the producer (lesser *r)*
- The more accurate the producers actions can be measured (lesser *V)*
- The more responsive the producer is to incentives (lesser $C''(a)$)

If the agent is risk neutral ($r = 0$) the optimal incentive scheme uses the marginal revenue as piece rate, $\beta = B'(a)$. This solution is often interpreted as the principal selling the firm to the agent.

3.8.2 Multiple tasks

With a few adjustments of the incentive intensity principles, it is possible to characterize the optimal incentives for a multi-task producer. The assumptions are the same as in appendix 3.8.1; only now the model should be viewed in several dimensions. The effort *a* now denotes a $n \times 1$ vector consisting of the effort allocated to the *n* different tasks, *B* is the processor's revenue as a function of the vector *a*, etc. Holmström and Milgrom (1991) developed the following formula for the optimal incentives, expressed through the $n \times 1$ vector β of relative weights assigned to the different tasks

$$\beta = \left(E + r\left[C_{ij}\right]\Sigma\right)^{-1} B'$$

Here, E is the unit matrix, $\left[C_{ij}\right]$ is a $n \times n$ matrix of second order derivatives of the cost function, Σ is the covariance matrix with dimension $n \times n$, and B' is a $n \times 1$ vector consisting of the principal's marginal revenue from the different activities. The basic observations on the incentive intensity in appendix 3.8.1 still apply. The structure of the cost function influences the incentives. If two activities are complementary, (i.e. $C_{12} < 0$), this motivates the use of strong incentives, since an increased incentive to engage in task 1 will automatically increase the effort towards task 2. On the other hand, the processor should be cautious with high-powered incentives if the activities are substitutes (i.e. $C_{12} > 0$) since the motivation of one activity easily ends up being at the expense of other activities.

3.8.3 Yardstick competition

The basic model of *yardstick competition* is Schleifer (1985). A yardstick-based cost reimbursement scheme based on linear programming, allowing production of multiple products by each producer, is developed in Bogetoft (1997).

Consider a simple production where the output of producer *i* depends on the effort a_i, specific noise ε_i and general noise ε that is common to all producers. The yardstick contract can be formally written as:

$$s_i = \alpha + \beta\left(x_i - \bar{x}_{\setminus i}\right)$$

where s_i is the payment to producer *i*, α and β are constants, $\bar{x}_{-i}$ is the average output from the *N-1* other producers, i.e. $\frac{N}{N-1}\sum_{j=1, j \neq i}^{N} x_j$. Inserting the production function $x_i = a_i + \varepsilon_i + \varepsilon$, the payment reduces to:

$$s_i = \alpha + \beta\left(a_i + \varepsilon_i - \bar{a}_{-i} - \bar{\varepsilon}_{-i}\right)$$

The equation shows that the general risk is eliminated from the payment.

CHAPTER 4.

Contract Production of Peas

Abstract

This paper analyzes a contract between farmers and the processor, Danisco Foods. Production of peas for consumption requires a highly accurate coordination, which is obtained through centralized decision-making. The contract is based on a tournament system providing risk sharing between the farmers. General problems known from contract theory such as hold-up, moral hazard, risk sharing, and discrimination are analyzed. The paper illustrates the trade-offs between these problems in the design of contracts. By negotiating the contract through The Pea Growers' Association, the farmers gain some bargaining power. Thereby the farmers can ensure that Danisco Foods uses only one contract for all farmers. This paper analyzes the consequences of the farmers' strategy. Throughout the analysis several modifications of the contract are suggested in order to improve the incentives.

4.1 Introduction

This chapter provides an in-depth analysis of a specific production contract. We analyze how different problems general to agricultural production contracts have been solved in the contract for production of peas for consumption (green peas) for Danisco Foods[1]. The contract has evolved through many years of experience. This means that the contract after a series of improvements has arrived at very clever solutions to general problems in contract design.

The contract must solve two fundamental problems. The first problem is the *moral hazard* problem, which exists because Danisco Foods cannot observe the actions taken by the farmers. This means that each farmer makes the decisions that maximize his own utility without considering the effects on Danisco Foods. This creates a need for incentives that will motivate the farmers to provide the effort that maximizes the integrated profit.

The second problem is *discrimination*, i.e. the problem of designing a contract that attracts the farmers with high reservation value without paying too much to farmers with low reservation value.

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[1] In September 2000 the Belgian company Ardo bought Danisco Foods A/S. In this chapter we analyze the situation before Danisco Foods was sold.

4.2 Background[2]

Danisco Foods has been involved in pea production for at least 50 years. Danisco Foods processes peas produced on 4,100 hectares, and is the only processor of peas for consumption in Denmark. The peas are processed in two factories owned by Danisco Foods. The peas are sold in different mixes of frozen vegetables to supermarket chains in Denmark and other European countries. There is a very small export of bulk. Danisco Foods experiences competition from foreign companies, because about 60 percent of the production is exported and because other companies sell on the Danish market. The impression within the industry is that the competition is tough due to over-capacity on the European market for frozen peas.

The timing of the harvest is extremely important for the outcome. If the peas are harvested too late, they will be over ripe and the taste will be ruined. If the peas are harvested too soon, the yield is too low. This means that the harvesting must be done within a range of 24 hours. Once the peas have been harvested they must be frozen within 4 hours to remain fresh.

These factors call for very accurate planning. The harvesting must be synchronized to match the capacity at the factory and the capacity of the harvest machinery, taking into account the transport time and the ripeness of the peas. To obtain an efficient harvest process, the decision-making is centralized. This means that Danisco Foods controls all decisions made during the harvest period. In order to plan the harvest, the sowing must also be done in the right order. To ensure this, the individual sowing time of each field is also decided by Danisco Foods.

For most farmers the contract production is a one-year relationship. The farmers can easily change their production plans and exclude peas from their production. Furthermore, peas can only be grown in the same field once every six years due to biological factors. For these reasons the contract is a one-year contract where the terms are adjusted every year. However, some farmers produce peas on contract year after year in different fields.

The producers are organized in The Pea Growers' Association. This is, however, a quite weak organization, since it has no means to enforce discipline. Danisco Foods has a large number of potential growers. If the association made a threat that no grower would sign the contract, Danisco Foods would be able to either go elsewhere or start signing contracts with the growers on an individual basis. This actually happened in 1996, when the association rejected the contract (The Pea Growers' Association, 1998). Danisco Foods is the only buyer of green peas from Danish farmers and thus holds almost all the bargaining power.

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[2] The description in this section is mainly based on an interview with the Senior Field Manager at Danisco Foods referred to as (Sørensen, 1998). Another important source is an interview of the Board and Secretary of The Pea Growers' Association (The Pea Growers' Association, 1998).

Danisco Foods considers the existence of The Pea Growers' Association to be an advantage, because the transaction costs are reduced. It is less expensive to write just one contract. A large part of the farmers are not able to see through the contract; these farmers only sign the contract because they have confidence in their negotiators. This means that the acceptance of the contract from The Pea Growers' Association works as a stamp of approval for the contract. Having the contract rejected by The Pea Growers' Association would be bad publicity for Danisco Foods. Furthermore The Pea Growers' Association shifts the contract relationship towards more long-term commitment[3]. These factors give The Pea Growers' Association some bargaining power which is used to reduce Danisco Foods' flexibility in contract design. This reduces the possibilities for Danisco Foods to discriminate between farmers of different types[4]. We analyze the issue of discrimination in section 4.4.5.

4.2.1 Chronology

The chronology of the process is:

- Negotiations between The Pea Growers' Association and Danisco Foods.
- Farmers communicate the size of the fields they want to use for contract production of peas. This is not legally binding.
- The contract negotiation between Danisco Foods and The Pea Growers' Association is completed.
- Danisco Foods sends out the standard contract to each farmer on a "take-it-or-leave-it" basis.
- The farmers sign (or reject) the contract, and select the fields for pea production.
- Danisco Foods inspects the fields offered by the farmers and chooses their contractees based on this inspection.
- Danisco Foods decides on the production plan, i.e. who to accept as producers and when the peas must be sowed.
- The farmers make the soil preparations and complete the sowing.
- The farmers are divided into groups.
- The farmers provide plant protection.
- Danisco Foods harvests the crop.
- The farmers are paid.

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[3] A long-term relationship reduces the risk of opportunism, see Williamson (1985) and section 3.5.3.

[4] The farmers argue for the use of only one contract from a fairness point of view. They demand equal treatment of all farmers ex ante.

4.3 The Contract

The farmer provides the land and is responsible for the soil preparations, the sowing and the plant protection during the growing season[5]. Danisco Foods decides the timing of sowing, provides advisory service, and harvest the peas. Danisco Foods does not only decide when the sowing must be done but also which varieties of seed the farmers should use.

Danisco Foods requires that each farmer keeps a log of his work. This enables Danisco Foods to document that, for a limited time before the harvest, the peas have not been exposed to pesticides.

Danisco Foods can decide that a farmer must try out a new variety on a small area. In these cases, the farmer is paid according to the regular payment scheme, but with a guarantee that he will get at least the same payment per hectare for the new variety as he obtains for the ordinary variety on the rest of his land. This means that the payment follows an option structure[6] with weaker incentives to the farmers, which may lead to conflicts of interest. However, Danisco Foods has never experienced any problems with farmers sowing new variety on the poorest land or undertaking an otherwise more risky production of a new variety.

Danisco Foods can refuse to accept peas from a farmer if, due to shirk, the peas cannot be processed. Except from damages caused by hail[7], the peas are never rejected for reasons outside the influence of the farmers[8].

The payment is determined in two steps. First the payment on factory level is determined, i.e. the total amount Danisco Foods must pay the farmers. Danisco Foods pays DKr 1.40 per kg. for the first 5500 kg. per hectare and DKr 0.55 per kg. for the remaining quantity. The farmers are guarantied a minimum of DKr 4800 per hectare. The factory payment is illustrated in Figure 4.3.1.

[5] The division of obligations described in the following is based on Danisco Foods (1998) and The Pea Growers' Association (1998).

[6] The payment to the farmer only depends on output if the yield on the new variety exceeds a certain level. This corresponds to the payment of a financial option.

[7] Most of the farmers have already insured their entire crop against damages from hail.

[8] This corresponds to what in the contract theory is known as *moving support*. Danisco Foods The Pea Growers' Association agree that peas are never rejected due to bad luck. The idea is that shirking can be avoided at no cost, if the punishment is harsh enough and if it is possible to detect shirking without any miscarriage of justice, see (Salanié, 1997) and section 3.5.2.

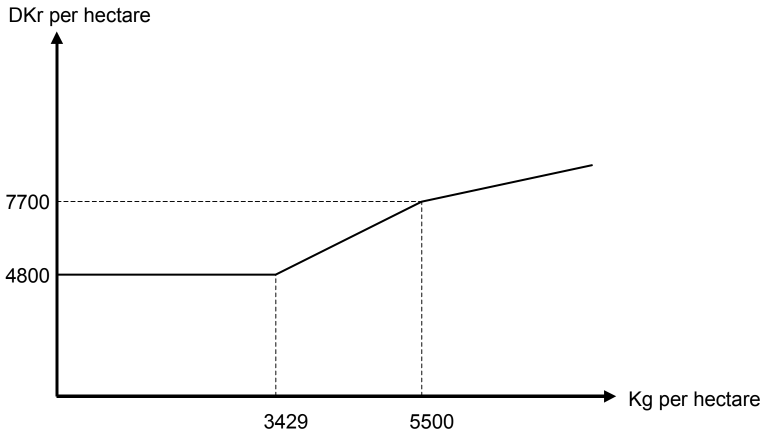

Figure 4.3.1 The factory payment

In the second step the factory payment is allocated between the farmers. The farmers are divided into groups according to which variety they use and at what time they sow the peas. This means that farmers in the same group experience the same production conditions, they use the same variety and sow at the same time. The average payment is the same in all groups. In each group the total payment is shared in proportion to the quantity delivered. And with a minimum payment of DKr 4800 per hectare, the individual farmer is facing a linear price scheme[9]. Figure 4.3.2 shows the payment scheme towards a farmer in three different groups, given an average production on factory level of 7500 kg. per hectare.

[9] In this graph the effect of an increase in the production of one farmer on the total factory payment and on the average production in his group is not included. If a farmer increases his production this will have two second order effects. Firstly, increased production raises the factory payment. Secondly, increased production reduces the payment per kg. in the group. Hence, the individual farmer does not face a totally linear payment scheme. The actual payment scheme is described in the appendix.

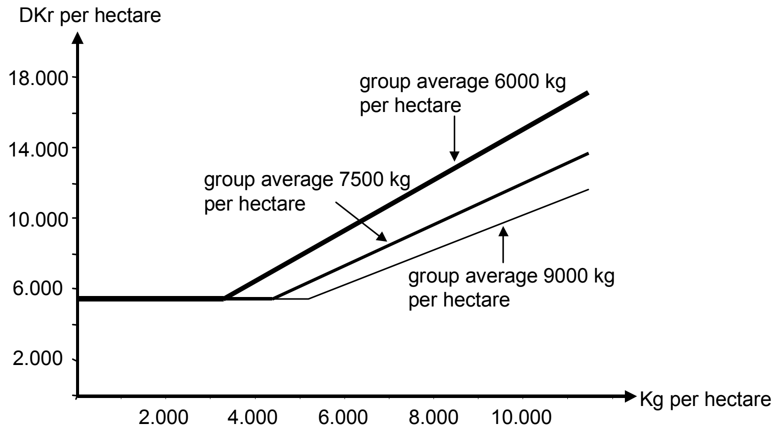

Figure 4.3.2 Impact of group average production on payment to a farmer

As shown in the figure, the average production in the group is very important to the farmer. This makes the division into groups an interesting issue, which we discuss in section 4.1.

If Danisco Foods is unable to harvest the peas at the right time, the company can decide to harvest the peas at full ripeness (used for animal feed). The payment to the farmer is not affected by this decision, i.e. Danisco Foods bears all risk derived from timing in the harvesting period.

The contract specifies that an arbitrator settles disputes arising out of the contracts.

4.4 Analysis of the Contract

In the following we analyze how the contract handles general challenges such as *coordination, hold-up*, *risk sharing*, *moral hazard* and *discrimination*.

4.4.1 Coordination

The production of peas requires precise coordination of the different stages of the production. In this contract the coordination is reached through a highly centralized decision-making, where Danisco Foods decides:

- Who to accept as producers
- The variety
- The amount of seed
- The timing of sowing and harvesting
- The production standards

The fields are inspected 3-4 times during the growing season. This gives Danisco Foods a high degree of control over the entire production process.

4.4.2 Hold-up

Danisco Foods has made very specific investments, including investments in the factories and in the harvest equipment. In a different context this could lead to hold-up problems, but since there are so many potential pea growers, there is no real risk of hold-up.

The farmers do not make any investments. There are no requirements for special machines or any special training. This eliminates the risk of Danisco Foods holding up the farmers.

4.4.3 Risk sharing

Risk sharing between the parties is an important aspect of contracts. The general idea in agency theory is that the principal (Danisco Foods) has a weaker risk aversion than the agent (the farmer), cf. section 3.4.2. In the present case, Danisco Foods is risk averse (Sørensen, 1998). However, several arguments suggest that Danisco Foods is a cheaper risk bearer than the farmers. Firstly, Danisco Foods has six other product lines and therefore a high diversification. Secondly, Danisco Foods is only one division of a large corporation Danisco A/S. Hence, the owners can diversify their investments on the capital market. It is difficult for the farmers to diversify their production due to positive correlation between the yields of different crops. The farmers' opportunities to diversify through capital investments are also limited.

In dividing the risk between Danisco Foods and the farmers there is a trade-off between optimal risk sharing, i.e. placing the entire risk on the party who can handle risk the cheapest, and the provision of incentives. An optimal risk sharing would be to pay the farmers a fixed wage, but this would not motivate the farmers to provide effort.

Sources of risk

In the analysis of risk sharing it is important to look at the types of risk in the production chain. Following the division in Holmström (1982) the production risk can be separated into general production risk and idiosyncratic risk. If it is cheaper for Danisco Foods to bear the risk than it is for the farmers, the company should take all risk except some fraction of the idiosyncratic risk, which the farmer must bear for incentive reasons (Holmström, 1982)[10].

[10] See also section 3.5.2.

In pea production the general production risk is the risk caused by weather conditions, general vermin attacks etc. The idiosyncratic risk is associated with those risk factors that affect the farmers differently, such as weeds etc.

In the production of peas, all farmers do not experience the same general production risk, because they use different varieties and sow at different times. This means that the general risk is primarily comparable between farmers within the same group.

Risk borne by Danisco Foods

The total payment from Danisco Foods to the farmers (the factory payment) is independent of marketing possibilities, i.e. the company bears all price risk[11]. From the start of the harvest period Danisco Foods bears all production risk, since the company faces the loss if a field is not harvested as green peas but at full ripeness. With these decisions being outside the influence of the farmers, this is exactly what contract theory predicts, because there is no trade-off between risk sharing and incentives.

The farmers are guaranteed a minimum average payment of DKr 4,800 per hectare. This means that Danisco Foods bears the general production risk of very low yields. Similarly, Danisco Foods bears much of the general production risk, when the average production is above 5500 kg. per hectare. The reason is that variations in the output on the last part of the payment curve only have a minor effect on the payment (see Figure 4.3.1)[12]. If the farmers had to take all the general production risk, the slope of the factory payment would be equal to the (expected) marginal value of peas to Danisco Foods. On the other hand, if the factory payment was independent of the output, Danisco Foods would bear all general production risk. The later system would correspond to the broiler production contracts in USA (Knoeber and Thurman, 1995).

[11] One can argue that the farmers bear some marketing risk, since their contracts will not be renewed if the production is no longer profitable to Danisco Foods.

[12] The kink in the payment scheme can alternatively be explained from a coordination point of view, since it gives weaker incentives to the farmers in good seasons. If Danico Foods' marginal value of peas is decreasing, it is reasonable to reduce the level of effort if the production is already high.

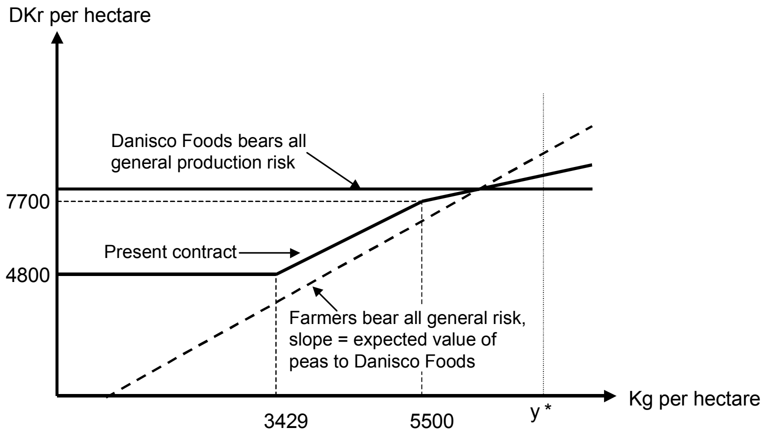

Figure 4.4.1 The factory payment and the general production risk

If the risk is borne cheapest by Danisco Foods, the system with constant factory payment will dominate the current contract. The reason is that Danisco Foods would gain from insuring producers against the general production risk and obtain the farmers risk premium. The figure shows that the payment for the expected production Y^* is lower the more risk Danisco Foods bears, since this reduces the farmers' risk premium. The ability to remove general risk from the payment to the farmers is one of the important arguments in favor of using tournaments in broiler contracts, cf. Knoeber (1989).

If the general production risk is severe, it may cause financial problems for Danisco Foods to bear general production risk in bad years, cf. section 3.4.2. The problem of possible bankruptcy may explain the actual contract between Danisco Foods and the farmers.

If Danisco Foods were to bear all the general risk, it may conflict with Danish agricultural law. The Danish agricultural law requires that the production risk is borne by the farmer (Wulf and Jørgensen, 1995)[13]. The legal aspects of the contract will not be analyzed further.

Risk shared among all farmers

The part of risk not borne by Danisco Foods is either shared between all farmers via pooling or placed on the individual farmer. As mentioned, Danisco Foods bears only part of the common production risk, since the factory payment is not constant. This leaves a fraction of the common production risk to the farmers. The farmers also bear a fraction of that risk, which is only common to the farmers within one group,

[13] The argument is that arrangements where the farmers do not bear the full production risk is considered a rental arrangement.

such as bad weather at the time of sowing. The reason is that low production in one group reduces the factory payment, but the farmers in the low yielding group receive the same average payment as the other groups.

New varieties are introduced in a way that causes no additional risk to the individual farmer, since Danisco Foods guarantees at least the same payment per hectare as for the ordinary varieties. However the factory payment will fall if a new variety has low yields because the total production will go down. Hence, Danisco Foods is both giving and taking, if a new variety has low yields. The net effect can be both positive and negative.

Risk borne by the individual farmer

Another source of risk is the division of farmers into groups. The payment to a farmer depends on how the groups are divided. If we consider the farmer in Figure 4.3.2 with same yield as the average for all farmers (7,500 kg. per hectare), his payment will vary from DKr 7,300 to 11,000 per hectare as the average production in his group varies from 9,000 to 6,000 kg. per hectare. This shows that the group division is important from a risk perspective. The group division is not arbitrary, but made so that farmers are only grouped with other farmers using the same variety. This means that most of the differences in yields across the groups is common to all farmers within one group (i.e. the deviation caused by difference in yields for different varieties). The larger the groups, the smaller the risk caused by group division due to the law of large numbers[14].

The payment to an individual farmer depends on idiosyncratic risks. This provides the farmer with incentives to ensure high production.

The farmer bears the risk of severe weed problems that occur only if the farmer shirks on the plant protection. This is supported by the argument of *moving support* from contract theory (see note 8).

4.4.4 Moral hazard

The production of peas involves many production decisions. This makes it difficult to specify and monitor the tasks of the farmers. It is therefore important to provide incentives for the farmers to perform in such a way that their hidden actions maximize the integrated profit. Possibilities for opportunistic behavior exist on both sides of the contract.

Opportunistic behavior from Danisco Foods

The negotiation process makes it important for Danisco Foods to maintain a good relationship with The Pea Growers' Association. This limits Danisco Foods possibilities to use its market power.

[14] Cf. part 3 of this thesis.

In a year where Danisco Foods foresees very bad marketing conditions, the company could be interested in reducing the quantity. The contract in principle gives Danisco Foods certain ways to do this. The company can reject more peas and blame it on weed, for example, but the arbitrator institution and the importance of the relationship with The Pea Growers' Association prevent such behavior. Another possibility would be to harvest a larger part of the peas at full ripeness and not as green peas. This approach is very expensive, since the value of ripe peas (hard peas used for animal feed) is much lower than the payment to the farmers. Thus, using harvest timing as an instrument in controlling the quantity is too expensive.

There is a conflict of interest between the farmers and Danisco Foods regarding the production planning. Overall, Danisco Foods wants the harvesting period to be as long as possible in order to utilize the capacity at the factory. For this reason Danisco Foods wants to have some farmers sowing very early and other farmers sowing very late even though this reduces the yields. On the other hand, the farmers want to choose the sowing time such that their yields are maximized and they do not take the factory capacity problems into consideration. If Danisco Foods tells one group of farmers to sow at a bad time, the total payment to the farmers decreases. This means that Danisco Foods pays only part of the costs caused by production planning (i.e. the time of sowing and the variety). Hence, Danisco Foods does not have an incentive to plan the production in a way that maximizes the integrated profit. A constant factory payment would place all costs of production planning on Danisco Foods and eliminate the conflict of interests regarding the time of sowing. Danisco Foods can implement a production plan without too much protest, since the loss caused by sowing at a bad time is shared between all farmers.

Opportunistic behavior from the farmers

It is impossible to specify and monitor all the farmers' actions. However, the farmers are quite limited in their set of possible production decisions. In reality the farmers cannot affect the quality of the peas, since Danisco Foods decides the variety, the amount of seed, etc. This means that quality is not a moral hazard issue in the production.

A problem in the use of tournaments is that the agents have incentives to collude and agree to provide low effort. This problem is solved in two ways. Firstly, the farmer do not know with whom to collude until after he has provided most of his effort, since the groups are not divided until after the sowing. Secondly, the groups change from year to year, i.e. the farmers do not get to know each other. The disadvantage of not knowing the group before the contract is signed is that the farmer has a very uncertain expectation concerning his payment, because he does not know whether he ends up in a group with high or low average yield.

4.4.5 Discrimination

The farmers must be compensated for their effort and the land they provide. The farmers are paid according to their production, regardless of whether a high production is a result of high effort or high soil quality. When deciding which soil types Danisco Foods wants to contract for, the company considers all cost, i.e. the payment to farmers as well as Danisco Foods' production costs. One example of such considerations is that the harvesting is cheaper on good soils (the fixed cost of harvesting an area, e.g. the cost of transporting the harvest machinery, is apportioned to a larger quantity). This means that it is most profitable for Danisco Foods to sign contracts with the farmers holding the best soil, even though these farmers also have higher reservation values[15] (Sørensen, 1998). It is therefore in the interest of Danisco Foods to design a contract that attracts the farmers with the best soils.

The total area contracted for is limited by the factory capacity. In an efficient setting, Danisco Foods will sign contracts for the areas with the largest difference between value of the area to Danisco Foods and the reservation value. Danisco Foods actually does contract with the farmers holding the best soil. This fact allows us to infer that the difference between the reservation value and the value to Danisco Foods is increasing in soil quality (Sørensen, 1998).

The following figures analyze how the soil quality affects the payment under the current contract and under modified contracts. We assume that the production follows the simple structure without risk $y_i = a_i + s_i$, where y_i is the output for farmer *i*, a_i is his level of effort and s_i his soil quality[16]. Furthermore we suppress the effort *a* in the figures by depicting the output for a soil type at the optimal level of effort, hence, in our model, there is a linear relation between soil quality and output. We assume that the soil quality is uniformly distributed. The payment per hectare is given by the yield times the price per kg. in the group[17], hence the payment is, under our assumptions, linear in the yields and thus in soil quality. Every year Danisco Foods rejects some farmers, with low soil quality, who are interested in a contract. This is because the payment to farmers with low quality soil is above their reservation value. It is hardest for Danisco Foods to attract the farmers with the best soils. We can infer from this information, that the reservation value must be convex in soil quality.

[15] The reservation value is the income the farmer can obtain in an alternative production.

[16] The soil quality does not follow ordinary measures of soil quality, it is a measure normalized for our purpose.

[17] We also assume that the individual farmer does not affect the price per kg. in his group.

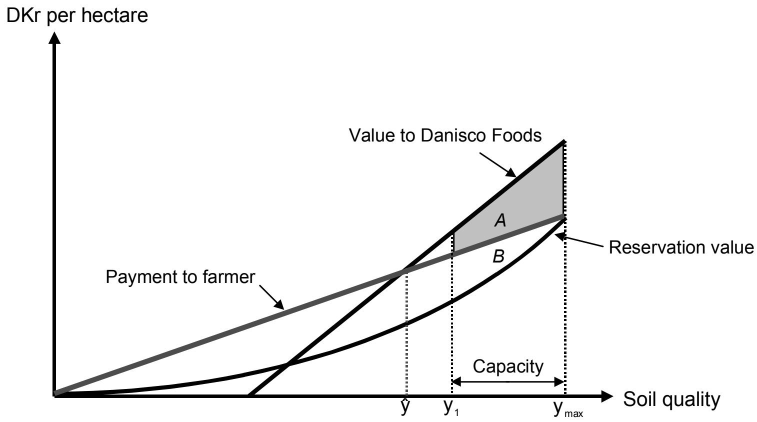

Figure 4.4.2 The payment to different soil types in the current contract

In Figure 4.4.2 *B* is the information rent to the farmers and *A* is the profit to Danisco Foods. According to the figure, it will be most profitable for Danisco Foods to utilize the capacity by signing contracts upon the soil types with (optimal) outputs between y_1 and $y_{\max}$. If Danisco Foods offers payment as shown in the graph, all farmers will be interested in a contract. However, Danisco Foods prefers soil types with outputs above y_1 and is not at all interested in soil types with outputs below $\hat{y}$. Danisco Foods has many years of experience in the industry and has much knowledge about the soil type based on the geographical location of the field. For this reason it is fair to assume that the company is able to detect and reject the types with outputs below y_1. This means that the problem of discrimination in this contact does not arise from *hidden information* as in standard adverse selection problems. Here the discrimination problem arises because Danisco Foods can use only one contract, i.e. a contract independent of the soil types.

Figure 4.4.2 shows that the farmers obtain the profit in area *B* because Danisco Foods cannot discriminate the farmers. If Danisco Foods could discriminate by changing the payment into an affine payment, in which the farmers receive a premium related to the quality of their soil, this would increase the profit to Danisco Foods. Figure 4.4. depicts an affine contract.

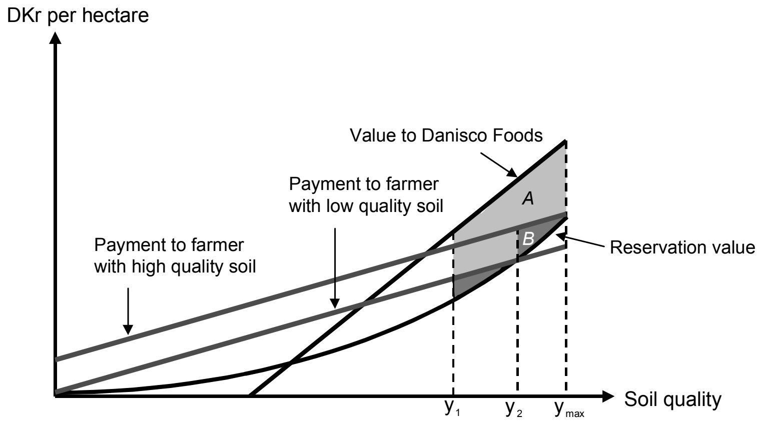

Figure 4.4. Payment to soil types differentiated by bonuses

As illustrated in Figure 4.4., Danisco Foods can increase its profit (area *A* in the figure) by offering a constant price per kg.[18] plus a bonus to soil types above y_2. The contract suggested in Figure 4.4. does not ensure self-selection, such that each farmer chooses the contract designed for his type. In the figure Danisco Foods offers just one contract to each farmer.

Figure 4.4.3 shows a set of contracts satisfying the self-selection constraint, such that each farmer selects the contract which Danisco Foods wants him to choose. Farmers with soil quality yielding an output below y_2 will prefer the contract designed for farmers with low soil quality, and vice versa for producers with high soil quality. In Figure 4.4.3 the price is used to discriminate, whereas the discrimination in Figure 4.4. is created by bonuses alone.

[18] The payment per kg. in the affine payment in the figure is lower than the originally payment, which reduces the incentives. The information rent to farmers could also be reduced by using the originally payment per kg. in Figure 4.4.2 to high quality soil combined with a negative bonus to low quality soil.

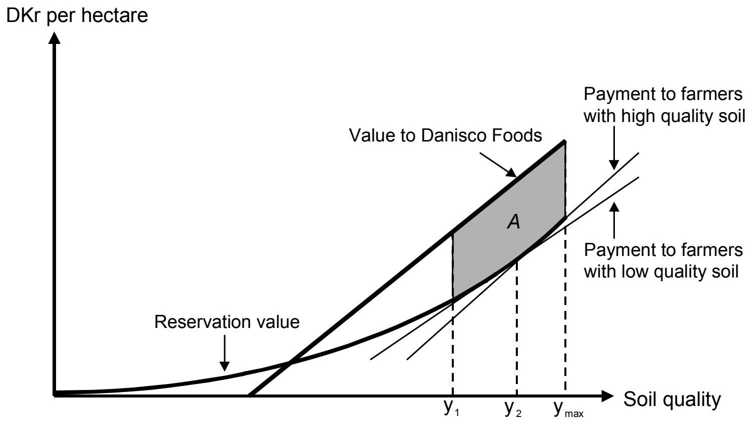

Figure 4.4.3 Differentiated payment to soil types based on different prices

The analysis shows the dilemma for Danisco Foods. If the company targets the current contract towards the best soils, and therefore pays the farmers with high quality soil a high price, farmers with lower soil quality will receive a payment that exceeds their reservation value (since the company is restricted to only one contract). There is a similar problem regarding farm size. If Danisco Foods raises the payment to attract more large farms in order to achieve the advantages of having large areas per farmer (to reduce the transport of the harvesting machines) all other farmers will benefit too. It would be beneficial for Danisco Foods to discriminate the farmers by using bonuses for high quality soil (Figure 4.4.), large farm size and location near the factory. However, the farmers resist this because it would remove their profits. The Pea Growers' Association has actually hindered the use of bonus payments to farmers with good soil and large areas (The Pea Growers' Association, 1998).

The payment per kg. in a group depends on the factory payment and on the average yield in the group. The groups are divided according to the harvesting route, so the farmers in one group are from the same area. This causes another problem, because the soil quality within one group tends to be positively correlated. The average payment per hectare to farmers in a group with high quality soils is equal to factory payment per hectare. Thus, the group composition may cause farmers in areas with good soil quality to profit more from producing other crops. If Danisco Foods still wants to contract upon the best soils, the factory payment must be raised. In reality, this turns out to be too costly for Danisco Foods, and as a result there has not been any contracts in a certain area with very good soil during some years (Sørensen, 1998).

If the payment were dependent on information about the soil type, the contract could be improved in yet two ways. First, the current contract may lead to a deadweight loss. In Figure 4.4.4 the profit to Danisco Foods increases (Danisco Foods loses *DF-1* but gains *DF-2*) if Danisco Foods reduces the payment to the farmers. Reducing the price to the farmers makes the contract unacceptable on the best soils (with outputs between y_2 and y_{max}), thus Danisco Foods will contract on the soils with outputs between y_0 and y_2. Reducing the payment to the farmers will however reduce the integrated profit[19].

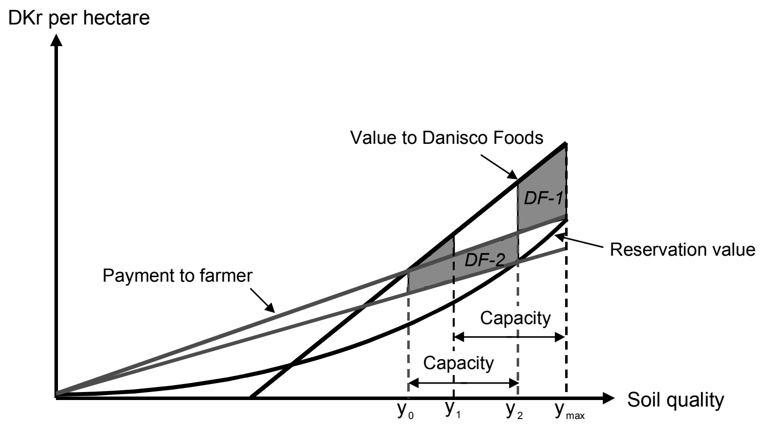

Figure 4.4.4 Deadweight loss due to uniform payment scheme

The second way information about soil quality can improve the contract is through more exact information about the effort. The idea is that the output level conditioned on the soil type contains information about the effort. This makes the implementation of the optimal effort less costly, because the uncertainty in the payment to the farmers can be reduced (Holmström, 1979)[20].

The information about soil quality may not be verifiable. If Danisco Foods commits to a constant factory payment[21], the non-verifiable information can be used in the contract, since the company has no incentives to misrepresent the information[22].

Given these advantages of conditioning the payment on the soil type, the Coase Theorem suggests[23], that the parties should reach a Pareto optimal agreement through negotiation and divide the benefits via side payments. One reason why the Coase Theorem may not hold in this case is that the farmers negotiating the current contract may not be accepted as growers in a contract based on soil types. It may not

[19] Note that $y_{\max} - y_1 = y_2 - y_1 = \text{capacity}$.
[20] Cf. section 3.5.2.
[21] Danisco Foods could commit to categorizing e.g. 50 per cent of the area as high quality.
[22] See Bogetoft (1994) for a general analysis of the use of non-verifiable information in contracts.
[23] Cf. Coase (1960).

be possible for Danisco Foods to compensate these farmers via side payments. This may cause the negotiations to break down.

4.4.6 How should the groups be divided?

The payment scheme makes the division of groups very important.

The factory payment is independent of the group composition, but the incentives and the allocation of the payment depends on the group division[24]. Danisco Foods is interested in as large fields as possible, since this will minimize the transport of the harvest machinery. The incentives in the current contract do not support this interest, because the incentives are weaker the larger the farm. If a farmer produces more, he reduces the payment per kg. in his group. This effect is largest in small groups. Thus, the incentives are stronger in a large group. This, of course, affects farmers with large productions (due to large areas or high yields) the most. Thus, the incentives are weaker, the larger the farm or the higher the yields. These results are shown in the appendix.

The effects of group size on the incentives and on the risk (cf. section 4.4.3) give arguments for large groups, which is in line with the policy of the company. However, the farmers are still divided into a considerable number of groups. There are two main reasons for this. First, the farmers are divided into groups based on the variety used. This prevents comparison of farmers using low yielding varieties and farmers using high yielding varieties. This is basically a fairness argument. This argument does not by itself explain the group division, since fairness could be achieved by using different premiums based on experimental results to the different varieties[25]. The second motivation for dividing the farmers into a number of groups is to obtain a more precise measure of the common risk in each group, since farmers sowing at different times experience different weather conditions. This means that the division into groups should be done according to the trade-off between strong incentives and precise measures of common uncertainty.

4.4.7 Yardstick competition

It is unfortunate that the incentives are very dependent on the group size and are weaker for larger producers. In yardstick competition the output of one farmer is compared to the average output of the other farmers in his group, i.e. the agents own output is not included in the average used for comparison (Schleifer, 1985). In the

[24] If Danisco Foods uses the group division as a discrimination mechanism for rewarding growers with high reservation value, Danisco Foods can attract all growers using a lower factory payment. In this case the factory payment depends on the division of groups, cf. part 3 of this thesis.

[25] This approach has actually been used by Danisco Foods. Previously Danisco Foods offered different prices to the varieties. The prices were determined before the contracts were signed. This system was abandoned because it resulted in too much variation in the payment (Sørensen, 1998).

appendix we show that (under the assumption that the factory payment is constant[26]) such a modification will imply that:

- The payment per kg. to a farmer is independent of his yield
- The incentives are independent of group size
- The incentives are independent of farm size.

The effect of using yardstick competition instead of the current contract is analyzed on the basis of data for the 111 farmers contracting with Danisco Foods in 1996. In Figure 4.4.5 the payment the farmers would obtain under yardstick competition (vertical axis) is plotted against the payment with current contract (horizontal axis) [27]. The figure shows that in general the farmers receiving the highest payment per hectare would gain if the current contract was replaced by yardstick competition, and the opposite holds for farmers with low payment per hectare. However, the largest deviation between the payments in the two systems is only 7 per cent.

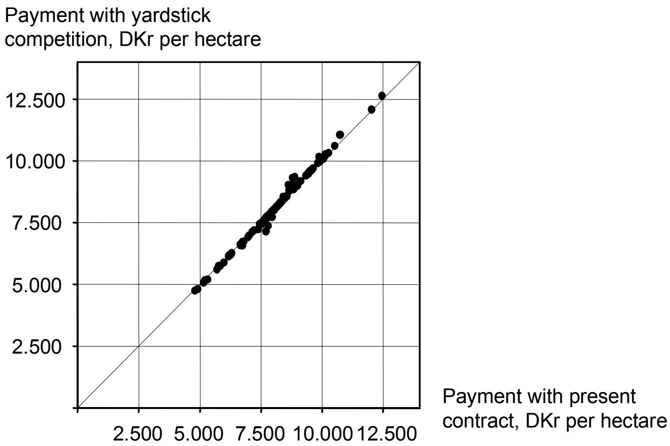

Figure 4.4.5 Comparison of payment to farmers, current contract vs. yardstick competition.

Even though the payments to the farmers is almost the same with the current contract and with yardstick competition, the modification would increase the incentives substantially. Figure 4.4.6 shows the marginal payment[28] in the current contract plotted against the marginal payment in yardstick competition. The largest increase in incentives is 115 per cent and is obtained by a farmer in a small group. The incentives increase for all farmers, even though the effects in large groups are rather limited.

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[26] See the discussion on page 173 of optimal risk sharing.

[27] Changes in production levels may alter this; the analysis is based on the old production levels.

[28] The marginal payment is the increase in payment from an increase in production of 1 kg. per hectare

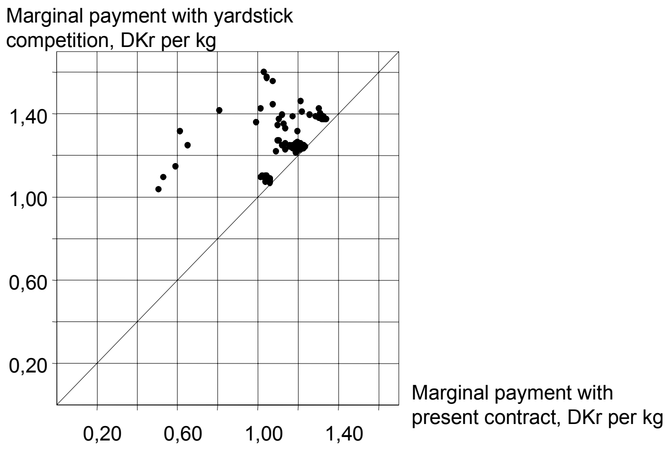

Figure 4.4.6 Comparing marginal payments, current contract vs. yardstick competition

The total payment to farmers is 0.25 per cent higher with yardstick competition than with the current contract. This is caused by positive correlation between farm size and yields. Hence, with yardstick competition, large farms would have stronger incentives than small farms. This is in the interest of Danisco Foods because large areas reduce the harvest costs. The disadvantage of the yardstick competition is that the payment to the individual farmer becomes more sensitive to variation in the yields of other producers.

4.5 Conclusion

The major motivation behind the contract is the issue of coordinating the production in the harvest period. This crucial coordination is obtained through centralized decision-making, where Danisco Foods makes all major decisions regarding the production.

There are no hold-up problems in the contract. Danisco Foods make specific investments, but the growers have very little bargaining power and cannot hold-up Danisco Foods. The farmers make no specific investments.

The payment to the farmers is determined in two steps. First, the total payment from Danisco Foods to all farmers is determined as a function of the average yield per hectare. Secondly, the farmers are divided into groups according to the time of sowing. The average payment per hectare is the same in all groups. In each group the payment is divided in proportion to the quantity of peas supplied by each farmer. This tournament system does not cause collusion problems, because the farmers do not know with whom to collude until after the sowing, i.e. when most of their work is done.

When the average production in the group is calculated, all farmers in the group are included. This paper shows that the incentives would improve if the average production, to which the farmers are being compared, did not include the farmer in question (yardstick competition). Calculations on actual data for 1996 show that, for some farmers, this would increase the incentives by more than 100 per cent.

Danisco Foods bears all price risk but only a small part of the production risk. From a theoretical point of view this seems to be disadvantageous, since several arguments suggest that Danisco Foods is the cheapest risk bearer. In order to shift all general production risk towards Danisco Foods it is suggested that the total payment from Danisco Foods to the farmers should be independent of the actual production level. In this way Danisco Foods can obtain the risk premium from the farmers by insuring them against general production risk. Another advantage of a constant total payment is that it reduces conflicts of interest between the farmers and Danisco Foods regarding the production plan.

It would be beneficial for Danisco Foods to discriminate between farmers by offering different contracts to farmers with different soil types. The contract does not use any bonuses, because The Pea Growers' Association has prevented the use of bonuses. This reduces the profit of Danisco Foods and may lead to deadweight losses, but the strategy increases the profit to the farmers.

4.6 Appendix

4.6.1 The Current Contract

Let x_i denote the area on farm *i=1,...,N*, and let q_i be the total production on farm *i*. We analyze the incentives for a farmer *t* in group *J*, $J \subseteq N$. The total factory payment *F* is given by:

$$F = \begin{cases} 4800\sum_{i\in N} x_i & \text{for average production below 3429 kg per hectare} \\ 1{,}4\sum_{i\in N} q_i & \text{for average production between 3429 and 5500 kg per hectare} \\ 7700\sum_{i\in N} x_i + 0{,}55\sum_{i\in N}\left(q_i - 5500x_i\right) & \text{for average production above 5500 kg per hectare} \end{cases}$$

The payment per kg. in group *J* is:

$$p_J = \frac{\sum_{i\in J} x_i}{\sum_{i\in N} x_i}\frac{F}{\sum_{i\in J} q_i} = \frac{X_J}{X_N}\frac{F}{Q_J}$$

where X_J denotes the total area in group *J*, X_N the total area for all farmers and Q_J is the total production in group *J*. The payment *B* to farmer *t* in group *J* is:

$$B_{Jt} = q_t p_J$$

The marginal payment is:

$$\frac{dB_{Jt}}{dq_t} = p_J + \frac{dp_J}{dq_t} q_t$$

since $p_J = \frac{X_J}{X_N}\frac{F}{Q_J}$ we have:

$$\frac{dB_{Jt}}{dq_t} = p_J + \frac{X_J}{X_N}\frac{\frac{dF}{dq_t}Q_J - F}{Q_J^{\ 2}} q_t = p_J + \frac{dF}{dq_t}\frac{X_J}{X_N}\frac{q_t}{Q_J} - \frac{X_J}{X_N}\frac{F}{Q_J}\frac{q_t}{Q_J}$$

$$= p_J + \underbrace{\frac{dF}{dq_t}\frac{X_J}{X_N}\frac{q_t}{Q_J}}_{\text{share of increase in factory payment}} - \underbrace{p_J\frac{q_t}{Q_J}}_{\text{share of price reduction in group J}}$$

The marginal payment is given by: the payment per kg. in the group plus farmer *t*'s share of the change in factory payment minus farmer *t*'s share of price reduction in his group. The marginal factory payment is never higher than the average payment:

$$\frac{dF}{dq} \le \frac{F}{\sum_{i\in N} q_i} \Rightarrow \frac{dF}{dq} \le \frac{F}{\sum_{i\in J} q_i} \Rightarrow \frac{dF}{dq}\frac{X_J}{X_N}\frac{q_t}{Q_J} \le \frac{F}{Q_J}\frac{X_J}{X_N}\frac{q_t}{Q_J}$$

$$\Downarrow$$

$$\frac{dF}{dq}\frac{X_J}{X_N}\frac{q_t}{Q_J} \le p_J\frac{q_t}{Q_J}$$

This means that:

A) $\frac{dB_{Jt}}{dq_t} \le p_J$, i.e. the farmers face lower incentives than the average payment per kg. in their group. In Figure 4.3.2 the actual payment scheme is therefore below the depicted curve.

B) $\frac{dB_{Jt}}{dq_t}$ decreases in q_t, i.e. the incentives are strongest for small producers.

Let $Q_{J\setminus t} = \sum_{i\in J} q_i - q_t$ be the production for all other producers in group *J except producer t*, and let y_t be the yield per hectare on farm *t*. Rewriting:

$$\frac{dF}{dq}\frac{X_J}{X_N}\frac{q_t}{Q_J} \le p_J\frac{q_t}{Q_J} \Leftrightarrow \frac{dF}{dq}\frac{X_J}{X_N}\frac{y_t x_t}{Q_{J\setminus t} + y_t x_t} \le p_J\frac{y_t x_t}{Q_{J\setminus t} + y_t x_t}$$

gives the results below (since $\frac{y_t x_t}{Q_{J\setminus t} + y_t x_t}$ increases in y_t).

C) $\frac{dB_{Jt}}{dq_t}$ decreases in y_t, i.e. the incentives are weaker the higher the yield.

Assuming that all farmers have the same yield y per hectare, the incentives marginal payment can be rewritten as:

$$\frac{dB_{Jt}}{dq_t} = p_J + \frac{dF}{dq_t}\frac{X_J}{X_N}\frac{yx_t}{yX_J} - p_j\frac{yx_t}{yX_J}$$

$$= \underbrace{p_J + \frac{dF}{dq_t}\frac{x_t}{X_N}}_{\text{independent of group size}} - p_j\frac{x_t}{X_J}$$

This means that:

D) $\frac{dB_{Jt}}{dq_t}$ increases in X_J, i.e. the incentives are stronger in large groups.

4.6.2 Yardstick Competition

We now consider a yardstick competition contract, where the individual farmer is excluded from the average of his group, when the price per kg. is determined. Hence, we change the payment to farmer *t* in group *J* from:

$$B_{Jt} = \underbrace{\frac{X_J}{X_N}\frac{F}{Q_J}}_{p_J} q_t$$

to the payment with yardstick competition:

$$\hat{B}_{Jt} = \underbrace{\frac{X_{J\backslash t}}{X_N}\frac{F}{Q_{J\backslash t}}}_{\hat{p}_{J\backslash t}} q_t$$

where $X_{J\backslash t} = \sum_{i\in J} x_i - x_t$.

The marginal payment in this contract is:

$$\frac{d\hat{B}_{Jt}}{dq_t} = \frac{X_{J\backslash t}}{X_N}\frac{F}{Q_{J\backslash t}} + \frac{X_{J\backslash t}}{X_N}\frac{1}{Q_{J\backslash t}}\frac{dF}{dq_t}q_t = \hat{p}_{J\backslash t} + \underbrace{\frac{X_{J\backslash t}}{X_N}\frac{q_t}{Q_{J\backslash t}}\frac{dF}{dq_t}}_{\substack{\text{share of increase in}\\ \text{factory payment}}}$$

since $\frac{X_{J\backslash t}}{X_N}\frac{F}{Q_{J\backslash t}}$ is independent of q_t.

A further modification of the contract, resulting in a constant payment from Danisco Foods (due to risk consideration, cf. section 4.4.3) i.e. $\frac{dF}{dq} = 0$, implies that the marginal payment $\frac{d\hat{B}_{Jt}}{dq_t} = \hat{p}_{J\backslash t}$ is independent of

- The farmers own yield
- Farm size
- Group size.

CHAPTER 5.

Contract Production of Special Pigs: Fixed or Market-determined Bonuses

Abstract

This chapter compares two bonus systems used by the cooperative, Danish Crown, to compensate producers of special pigs. The market-determined bonus increases with the share of the special pig production sold as special pigs. The fixed bonus does not depend on the extent to which the special pigs are actually sold as special pigs. We show that the two bonus systems lead to different conflicts between special producers and standard producers (the majority in the cooperative held by the latter). The market-determined bonus system creates conflicts concerning the sale of special pigs. In this system, the standard producers have incentives to lower the sales of special pigs. The fixed bonus system creates conflicts regarding the production level. In this system, the standard producers have incentives to reduce the production of special pigs. We show that the market-determined bonus is the most profitable system for the standard producers – but not necessarily for the special producers or for the cooperative as a whole. We use empirical data to quantify the effects of using one system or the other.

5.1 Introduction

The pig industry plays a very important role in Danish Agriculture. Almost 30 percent of the total farm income in Denmark comes from the pig production. Danish farmers produce more than 22 million pigs per year. More than 80 percent of this production is exported. This makes Denmark one of the world's leading exporters of pork (Farmers Union, 2000).

The pig industry is undergoing an interesting transition. For decades the pig industry specialized in producing a homogeneous standard pig (also called multi-pig). The strategy was that different parts of the standard pig were sold to different markets and that the adaptation to specific markets occcured only in the processing.

During the last decade, there has been an increase in the production of special pigs aimed at different market segments. The special pigs are differentiated at the farm-level. Often the differentiation is based on soft values such as animal welfare, which cannot be observed in the final product. Hence, the slaughterhouse must be able to document that the products are differentiated throughout the entire production chain. The transition in the pig industry is accompanied by an interesting evolution in the contracts governing the special productions.

The largest special production is by far the UK pigs (12 percent of all pigs produced). Producers of UK pigs must fulfill certain requirements with respect to animal welfare for the sows. The sows must be kept untethered from weaning until seven days before farrowing. The second largest special production is the EU heavyweight pigs (4 percent of the production). These pigs are aimed at the market for fresh meat in Europe. In addition to the UK and EU heavyweight pigs, there are a number of different special pigs aimed at the domestic market. These pigs fulfill different requirements with respect to animal welfare, feeding etc. Special pigs aimed at the domestic market account for less than 2 percent of the pigs slaughtered by Danish Crown. Most of the special pigs for the domestic market are produced under the National Special Label (NSL), originally introduced and monitored by the Ministry of Food.

Type of pig	Bonus, DKr per kg (live weight)
Multi pigs	81
UK pigs	12
EU heavyweight pigs	4.3
Italian pigs	1.2
National Special Label - NSL	1.0
Organic Pigs	0.2
Outdoor Pigs	0.4

Table 5.1.1 Different types of pigs processed by Danish Crown

Pig production involves two phases: the production of piglets and the fattening of pigs. Often, producers control only one of these phases. Most requirements in the special production concern the production of piglets. The contracts are three-part contracts between the slaughterhouse, the finisher and the producer of piglets. The bonuses and penalties are almost entirely aimed at the finisher. In this paper we do not consider the contracts between the producer of piglets and the finisher[1].

Almost the entire pig production in Denmark (96 percent) is slaughtered by three cooperatives. Danish Crown is by far the largest cooperative and handles 78 percent of the pig slaughtering[2]. Danish Crown also handles 60 percent of the cattle slaughtering in Denmark. Danish Crown has reached this market position through mergers and acquisitions. For instance, Danish Crown has acquired the majority holding (60 percent) in Friland Foods Ltd., which hold contract production of

1 Graversen (1999) gives an analysis of these contracts.

2 Danish Crown has recently proposed a merger with the second largest slaughterhouse, Steff Houlberg, cf. Danish Crown (2001).

organic pigs and other special pigs. In this paper we do not consider the contracts of Friland Foods.

The settlement prices in Danish Crown are determined under a balanced budget constraint, since the cooperative must pay out all profit[3] to the members. The payment consists of a base payment and a supplementary payment. The base payment is adjusted weekly and reflects the income in the past week. At the end of the financial year the members determine the supplementary payment for the year, see Bogetoft and Olesen (2000).

The producers of special pigs receive bonuses in addition to the base payment paid to all producers, standard and special producers alike. Danish Crown uses two types of bonuses, fixed bonuses and market-determined bonuses.

The market-determined bonus increases with the share of the special pig production sold as special pigs – and not just as standard pigs. The fixed bonus does not depend on the extent to which the pigs are actually sold as special pigs.

According to the official policy of Danish Crown[4], the fixed bonus equals the additional cost of producing special pigs instead of standard pigs. Fixed bonuses are independent of the actual sale of special pigs.

Market-determined bonuses are used for NSL pigs only, while all other special pigs receive a fixed bonus[5]. The market-determined bonus system used for NSL pigs is illustrated in Figure 1.

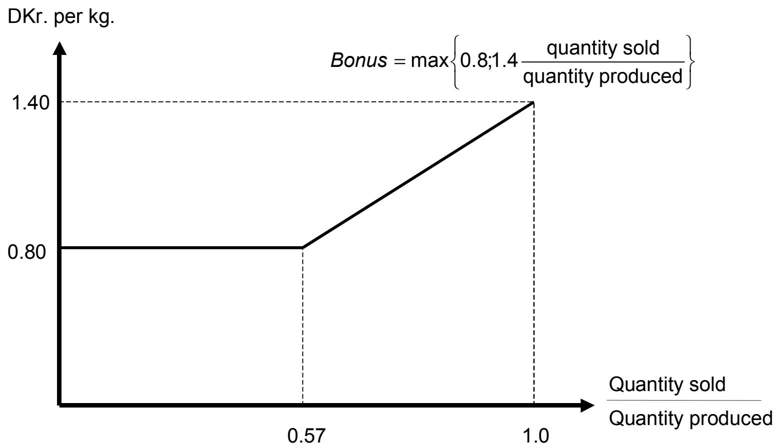

Figure 5.1.1 The market-determined bonus system

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[3] Except some fraction of the profit used for investments and consolidation.

[4] Flemin (2001).

[5] Organic producers receive a combination of fixed and market-determined bonus, though. Friland Food handles the organic production.

In this paper we analyze the contracts used for special pigs and in particular, we compare the relative merits of using fixed vs. market-determined bonuses. The analysis is based on three general criteria, viz. coordination, motivation and transaction costs.

5.2 Coordination

There is no quantitative restriction on the delivery of standard pigs; i.e. the producers can freely choose their production levels. The contracts on special pigs include quantitative restrictions. However, the contracts allow for a variation in supply of +/- 30 percent.

To ensure efficient logistics[6], only producers near a slaughterhouse processing a given type of special pigs can deliver this type of special pig. This means that producers with a comparative advantage in the production of a certain type of special pig do not automatically have the right to produce it. This may create production inefficiencies, at least in the short run, as the most efficient producers of special pigs may not be allowed to produce them. Logistics may be optimized at the cost of production efficiency.

Over time, producers will adopt production technologies suited for the special pigs produced in their area. In the long run the policy of only allowing producers in certain areas to produce certain types of pigs will lead to a differentiation in the adoption of technologies. The all-in-all-out production, where the production buildings are emptied between each flock, is especially profitable in the production of EU heavyweight pigs[7]. Therefore, producers near a slaughterhouse handling EU heavyweight pigs will, in the long run, be more likely to adopt all-in-all-out production technologies than producers in other areas. There is no apparent reason to expect producers in a certain area to be more efficient in the production of EU heavyweight pigs than the producers in other areas of the country. In the long run therefore, the production costs are probably independent of the geographical location of the production. Hence, the geographical restrictions are not likely to create production inefficiencies in the long run.

The Danish dairies have chosen a different approach. Each producer can choose between producing organic or conventional milk. If the dairies restricted the production of organic milk to certain geographical areas the transport costs would fall[8]. On the other hand concentrating the organic milk production would increase the production costs for organic milk, because the concentration would create a shortage of certain inputs. For example, organic milk production requires a fairly large amount of straw in the production. The straw is typically bought from conventional

[6] The slaughterhouse pays the transport costs.
[7] See Graversen (1999).
[8] The dairies pay the transport costs.

producers. If the production of organic milk was concentrated in one area, the price of straw and thereby the production costs would increase.

Geographical concentration of special production improves the logistics. If the production costs are not affected by a concentration, we therefore expect geographical restrictions (like in the case of special pigs). On the other hand, if production costs increase with the concentration (like in case of organic milk), it is preferable to avoid geographical restrictions and accept the higher transport and processing costs.

5.3 Market-determined Bonus

The market-determined bonus system guarantees the producers a minimum bonus of DKr 0.8 per kg. The market-determined bonus gradually increases to reach DKr 1.4 per kg. when all special pigs are sold as special pigs.

Formally, the bonus per kg. of special pig is given by

$$B(S,Q) = \max\left(0.8, 1.4\frac{S}{Q}\right) = \begin{cases} 1.4S/Q & \text{if } S > 0.57Q \\ 0.8 & \text{if } S \leq 0.57Q \end{cases}$$

where Q is the production of special pigs in kg, and S is the quantity, also in kg, sold as special pigs. Hence, if less than 57 percent of the special pigs are sold as special pigs (the remaining 43 percent, or more, being sold as standard pigs) the market-determined bonus is DKr 0.80 per kg.

The market-determined bonus has a number of interesting implications. In the following we analyze the impact on:

- The sale of special pigs
- The production of special pigs
- The participation constraints
- The risk sharing
- The influence costs

The analytical solution to a general formulation of the market-determined bonus system is provided in the appendix. Here, we illustrate the solution with the specific parameters used by Danish Crown.

Before we turn to a more specific analysis of the aspects mentioned above, we make a few simple observations.

The special producers receiving the market-determined bonus are a small minority (only a few percent of the members in the cooperative). Hence, the standard producers have a clear majority vote in the cooperative and they can in reality make all decisions not specified by the contract. In particular, the standard producers can determine the share of special pigs that is sold on the special market.

In modeling the problem we assume that the pigs not sold on the special market are sold as standard pigs at a constant world market price P_w and that the market for special pigs is independent of the market for standard pigs. We also assume that there are no positive or negative synergies between special and standard pigs in the processing and sales, i.e. the quantity of one type of pigs does not affect the costs of processing the other type. These assumptions enable us to trace the effects of the market-determined bonus in a fairly simple model.

5.3.1 Sales

When the standard producers determine how to sell the production of special pigs, they consider the effects on the total revenue and the effects on the allocation of the revenue. To understand this, note that if the cooperative increases the sale of special pigs, three effects come into play:

1) The sales revenue changes (increases if the marginal revenue on the special market exceeds the world market price).
2) The market-determined bonus increases (at least weakly).
3) The production of special pigs increases as a consequence of higher bonus.

The *integrated* profit is optimal when the marginal revenue is equal to the marginal cost. The sales and production quantity $\left(S^{FB}, Q^{FB}\right)$ that maximizes the integrated profit is given by

$$\left(S^{FB}, Q^{FB}\right) = \arg\max_{S,Q}\left[R(S,Q) - C(Q)\right]$$

where $R(S,Q)$ is the sales revenue (net of any processing costs) from the production of special pigs when the quantity S is being sold as special pigs and the quantity Q-S is sold as standard pigs, i.e. $R(Q,S) = P_S S + P_w(Q - S)$. $C(Q)$ is the primary production costs from producing Q special pigs[9].

It is not optimal to produce special pigs that are sold as standard pigs, since special pigs are more costly to produce. Therefore, the production should equal the sale $\left(S^{FB} = Q^{FB}\right)$ and we can rewrite the problem as

$$S^{FB} = \arg\max_{S}\left\{R(S,S) - C(S)\right\}$$

If the goal of the co-operative were to *maximize revenues*, the sale of special pigs would be

$$\overline{S}(Q) = \arg\max_{S}\left\{R(S,Q)\right\}$$

[9] More precisely *C(Q)* is the lowest possible cost of producing *Q*, i.e. the production costs when the production *Q* is allocated efficiently among the special producers.

The majority in the cooperative optimize the *standard producers' profit*. In doing this, the standard producers consider the impact on revenue and bonus payment; i.e. they consider effect 1 and 2 and equate marginal revenue to marginal bonus payment. Thus, the standard producers choose

$$S(Q) = \arg\max_{S}\{R(S,Q) - B(S,Q)Q\}$$

where B is the bonus per kg. of special pigs produced and $S(Q)$ denotes the sales volume selected by the standard producers.

Figure 2 illustrates the interaction between marginal revenues and bonuses in the market-determined bonus system. The formulas behind the graphs are derived in the appendix.

The upper left graph depicts the marginal revenue from sale of special pigs, i.e. $\frac{\partial}{\partial S}[P_s(S)\cdot S] = MR(S)$. The graph shows how the sale of special pigs is determined as a function of the world market price. $\bar{S}$ is the revenue maximizing quantity and $\underline{S}$ is the quantity chosen by the standard producers when the marginal bonus payment (i.e. the increase in the total bonus when the sale on the special market S increase by 1 kg.) is DKr 1.40 per kg.

The upper right graph shows the sale of special pigs selected by the standard producers as a function of the production of special pigs, i.e. $S(Q)$.

The lower figure shows the corresponding market-determined bonus per kg. of special pigs produced as a function of the production and the sale of special hogs, i.e. $B(S(Q),Q)$.

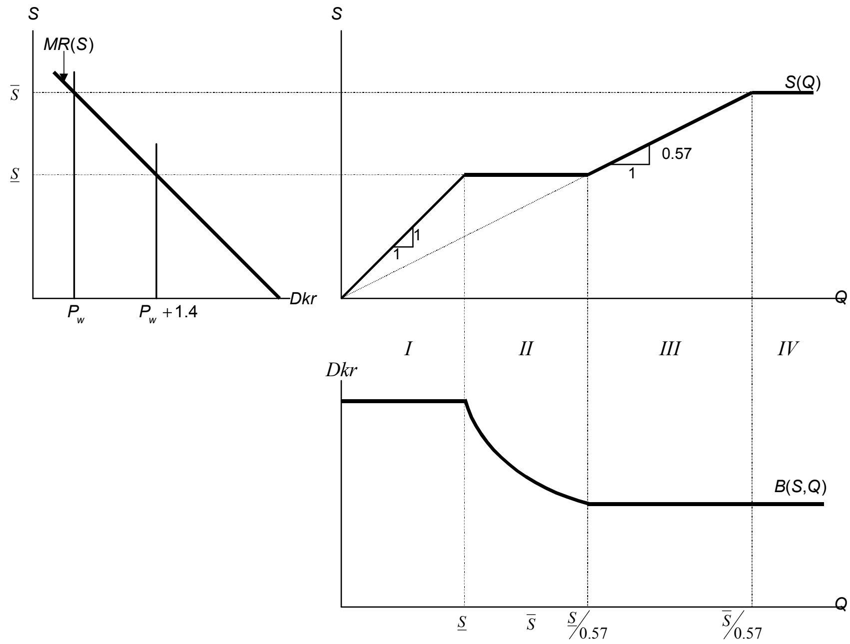

Figure 5.3.1 Determining sales and market-determined bonus

The sale of special pigs determined by the standard producers, i.e. $S(Q)$, can be divided into four intervals according to the production level.

In interval *I* where the production of special pigs is between *0* and $\underline{S}$, the price of special pigs is so high that the standard producers sell the entire production as special pigs. Thus, the bonus is DKr 1.4 per kg of special pigs in interval *I*.

In interval *II* where the production is between $\underline{S}$ and $\underline{S}/0.57$, the standard producers do not want to increase the sale of special pigs beyond $\underline{S}$. The reason is that increasing the sale of special pigs by one kg will increase the bonus payment to the special producers by DKr 1.4. Hence, additional sales on the special market is not beneficial for the standard producers, because the difference between the marginal revenue on the special market $MR(S)$ and world market price P_w is less than DKr 1.4 per kg. The bonus is between DKr 0.8 and 1.4 per kg in interval *II*.

In interval *III* where the production is between $\underline{S}/0.57$ and $\overline{S}/0.57$, the sale of special pigs is so low relative to the production that the market-determined bonus is at the minimum level (i.e. DKr 0.8 per kg). However, the marginal revenue on the special market exceeds the world market price, so higher sale of special pigs increases the sales revenue. As the production increases in interval *III*, the sale of special pigs can increase without affecting the bonus (which remains at DKr 0.80 per kg.), if the sale of special pigs goes up by 0.57 when the production increases by

1. In interval *III* the total bonus payment $Q \times B(S,Q)$ is at the minimum level such that $0.8Q = 1.4S$, this is achieved by choosing $S = \frac{0.8}{1.4}Q = 0.57Q$.

In interval *IV* where the production exceeds $\overline{S}/0.57$, the full potential of the special market has been exploited. Hence, increasing the sale of special pigs will in fact reduce the sales revenue, because the marginal revenue on the special market $MR(S)$ is below the world market price P_w. For this reason the sale of special pigs remains at $\overline{S}$ in interval IV.

Notice that sale and production only increases in the ratio of 1:1 in interval *I*. In the other intervals (when the utilization is below 100 percent) increasing the production by one pig will increase the sale by less than one pig. Hence, the problem of excess production (pigs produced as special pigs but sold as standard pigs) increases when the production goes up.

Whether the cooperative actually distorts the sale of special pigs or not, depends on which role the producers play in the marketing decisions. If a revenue maximizing sales manager makes all marketing decisions, the market-determined bonus system does not distort the sale. In other words, the distortion in the marketing decisions can be seen as a cost of active ownership. It is unlikely that the owners of the cooperative (i.e. the producers) do not affect the marketing decisions.

5.3.2 Production

The standard producers have no incentive to regulate the production of special pigs as long as the production is in interval *II* (i.e. utilization between 57 and 100 percent). In interval *II* the total bonus to the special producers depends only on the sale of special pigs *S* and not on the production of special pigs *Q*. In interval *II* the standard producers let the special producers determine the production level *Q*. This is illustrated in Figure 5.3.2.

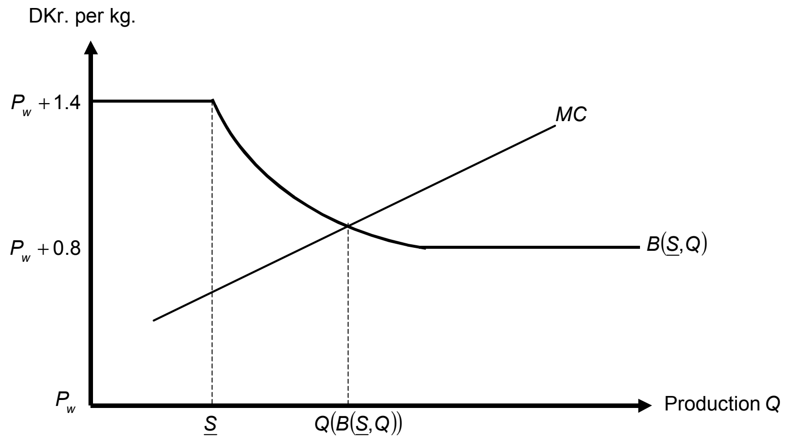

Figure 5.3.2 The production level with market-determined bonus

In interval *III* and *IV* where the utilization is below 57 percent the standard producers have an incentive to terminate contracts on special pigs[10] and thereby reduce the production to $Q = \underline{S}/0.57$. Similarly, the standard producers will want higher production of special pigs if the production is in interval *I*, i.e. $Q < \underline{S}$. Proofs are provided in the appendix.

In the intervals *I* (100 percent utilization) and *III+IV* (utilization below 57 percent), fluctuations in the demand for special pigs do not change the bonus. Thus, in such cases, the market-determined bonus does not transmit demand signals to the special producers. In other words, the market-determined bonus does not transmit demand signals when there is no excess production or when the excess production is very large.

In interval *II* where the utilization of special pigs is between 57 and 100 percent, the incentives to produce special pigs vary with the demand for special pigs. Higher demand for special pigs will increase the sale of special pigs and thereby the market-determined bonus. Thus, higher demand for special pigs leads to higher bonus and thus a higher production of special pigs. This may seem to be an attractive feature. However, as long as the utilization of special pigs is below 100 percent, there is no reason to increase the production. Increasing the production when not all special pigs are sold as special pigs generate unnecessary production costs. This is illustrated in Figure 5.3.3 where the shaded area illustrate the additional distortion in production cost, when the sale increases from *S* to *S'* due to higher demand for special pigs.

[10] The notice of termination is 6 months.

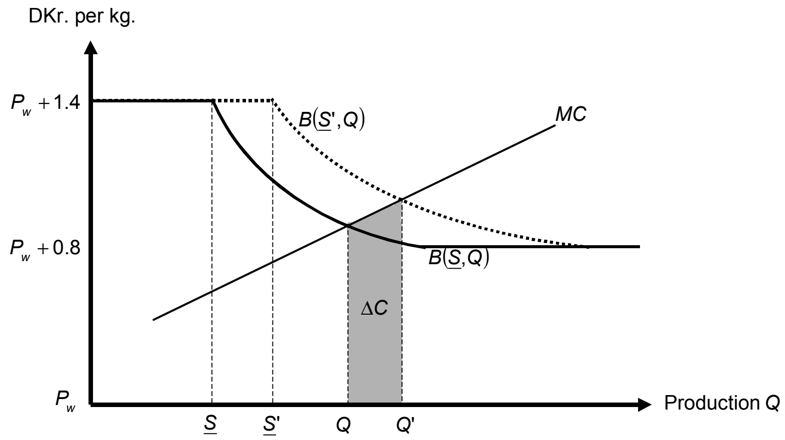

Figure 5.3.3 Production adjustment when the demand for special pigs increases

If the world market price decreases, other things being equal, in a situation where the production exceeds the sale of special pigs, the market-determined bonus increases. Hence the producers cannot always interpret an increase in the market-determined bonus as an indication of higher demand for special pigs.

It is worth noting that maximizing sales revenues does not lead to optimal integrated profit. In fact, the revenue-maximizing sale of special pigs may lead to a smaller integrated profit than the solution preferred by the standard producers. This illustrates the observation that the sales decisions in a cooperative should not be considered independent of the producers' production decisions. Hence, maximizing the sales revenue is not always an appropriate goal for the management in cooperatives[11]. The problem is illustrated in Figure 5.3.4.

[11] See Bogetoft and Olesen (2000) for a thorough discussion of this result.

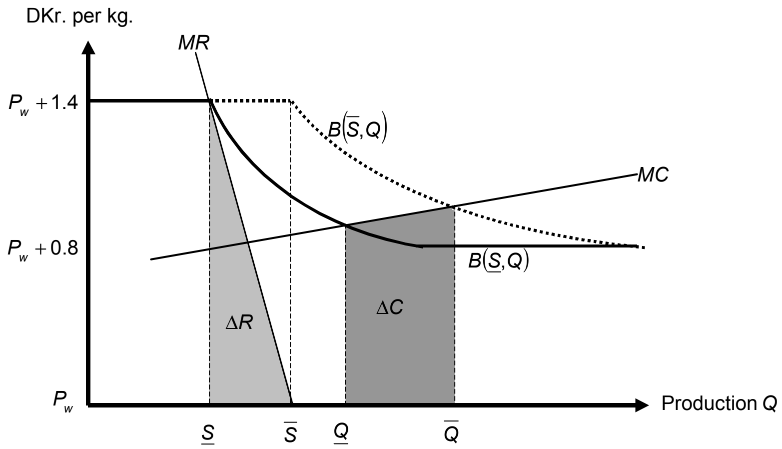

Figure 5.3.4 Losses and gains from revenue maximization

In Figure 5.3.4 the net effect on the integrated profit from choosing the revenue-maximizing sale rather than the sale preferred by the standard producers is $\Delta R - \Delta C$, which in the figure is negative.

5.3.3 Participation

In order to exploit synergies it should be profitable for all members to stay in the cooperative. In particular, the payment scheme should be robust against threats of collective resignation from the cooperative by producer groups. For example, the payment should ensure that the special producers are not better off outside the cooperative. This is achieved if the resulting profit allocation belongs in the core, cf. Young (1985).

The requirement of the core states that no coalitions of producers should obtain a profit smaller than the coalition's stand-alone profit, i.e. the amount of profit which the coalition can obtain outside the cooperative. This is equivalent to requiring that no coalition of producers receive more profit than the coalition's contribution to the cooperative, i.e. the amount by which the integrated profit would fall if the coalition resigned from the cooperative.

Figure 5.3.5 illustrates the core. The profit allocated to the standard producers can be read from left to right, while the profit allocated to the special producers can be read from right to left. The length of the line segment reflects the total integrated profit of the cooperative. The core is the set of allocations in the interval where both standard and special producers receive at least their stand-alone profit.

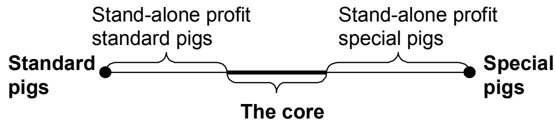

Figure 5.3.5 Allocation between multi-pigs and special pigs

The requirement that the profit allocation shall belong in the core must hold in a dynamic setting. This means that when the demand for special pigs increases, the payment to the special producers must also increase to avoid situations where the special producers are better off outside the cooperative.

When the utilization of special pigs is between 57 and 100 percent, the market-determined bonus ensures that an increase in the demand for special pigs benefits the special producers. This means that the profit allocation is likely to stay within the core when the demand for special pigs changes. In fact, when Danish Crown introduced the market-determined bonus, one of the official arguments was that "*the bonus system prevents that other producers subsidize NSL-producers when sales are low*" (Danish Crown, 1999). This is equivalent to ensuring that the profit allocation belongs in the core.

The market-determined bonus can also be seen as a compromise between producer groups with different expectations about the demand for special pigs. If the producers of special pigs have high expectations about the future demand for special pigs, they will, ex ante, be willing to sacrifice some potential income when the demand is low (i.e. the state they ascribe a low probability) in exchange for some income when the demand is high (i.e. the state they ascribe a high probability). On the other hand, if the standard producers do not expect a high demand for special pigs, they will be more willing, ex ante, to sacrifice some income when the demand is high in exchange for some income, when the demand is low. Hence, the market-determined bonus can be an ex ante favorable bet between two producer groups with different expectations (subjective probabilities) because the producer groups have different trade-offs on income in the different states (high and low demand)[12].

5.3.4 Risk sharing

A reduction in the world market price will increase the sale of special pigs and thereby the market-determined bonus. Hence, the special producers will be exposed to a smaller decrease in their total payment (i.e. base payment plus market-determined bonus) than the standard producers[13]. Thus, there is not full risk sharing between the special producers and the standard producers with respect to changes in the world market price.

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[12] This idea is discussed in Bogetoft (1998).

[13] In some cases the total payment may in fact increase.

If the demand for special pigs decreases, the market-determined bonus will fall when the production is in interval *II* (utilization above 57 percent). Thus, the special producers are worse off if the demand for special pigs fall. The standard producers will obtain lower revenue from the special pigs, if the demand for special pigs falls, but they also pay a lower bonus to the special producers. However, the net effect for the standard producers is negative, causing the base payment received by both standard and special producers to fall[14]. Hence, the standard producers bear part of the risk regarding the demand for special pigs. If less than 57 percent of the special pigs are utilized (interval *III+IV*), the risk of lower demand for special pigs is shared among all producers.

5.3.5 Influence costs

Influence costs play an important role in the design of payment schemes in cooperatives[15]. The advantage of the market-determined bonus system in relation to influence costs is that the total bonus is independent of the production in interval *II* (when the utilization of special pigs is between 57 and 100 percent)[16]. This means that the standard producers have no interest in regulating the special production. Thus the cooperative can avoid spending time on internal discussions about the size of the special production.

On the other hand the producer groups have different interests regarding the sale of special pigs, as discussed above.

5.4 Fixed Bonus

Danish Crown uses fixed bonuses for UK pigs and EU heavyweight pigs. In the following we analyze how fixed bonuses affect the sale, production, participation, risk and transaction costs.

5.4.1 Sales

Under the fixed bonus system the standard producers choose the sale of special pigs so that the revenue from special pigs is maximized, i.e. they choose

$$\overline{S}(Q) = \arg\max_{S} \{R(S,Q)\}$$

---

[14] Proof: let $\hat{S}$ be the quantity sold on the special market by the cooperative at price $\hat{P}_S$ when the demand is low. The cooperative can still sell $\hat{S}$ at price $\hat{P}_S$, when the demand is high. If the majority chooses a different sales quantity or a different price when the demand is high, it must generate higher net revenue. Thus the net revenue cannot fall when the demand increases.

[15] Cf. Hansmann (1996) and Bogetoft and Olesen (2000).

[16] Cf. the appendix.

In other words: under fixed bonuses, the standard producers choose the revenue-maximizing sale of special pigs so that the special pigs are sold on the special market as long as the marginal revenue on the special market exceeds the world market price for standard pigs. Hence the sale is given by $\overline{S}(Q) = \min\{Q, \overline{S}\}$, cf. Figure 5.3.1.

5.4.2 Production

The total bonus payment to the special producers, determined by the fixed bonus system, is $\overline{B}Q$. This means that the standard producers have incentive to avoid excess production of special pigs (i.e. ensure $S = Q$). In fact, the standard producers prefer that the production level of special pigs is where the marginal revenue of special pigs equals the world market price plus the fixed bonus. Hence, the standard producers solve the following problem:

$$\max_{Q}\{R(Q,Q) - \overline{B}Q\} = \max_{Q}\{R(Q,Q) - 1.1Q\}$$

when the fixed bonus is DKr 1.1 per kg.

However, it is difficult for the standard producers to control the special production precisely. There are two main reasons for this. First, the special producers are allowed to vary their production by +/- 30 percent. Second, it will become difficult and expensive to attract new special producers if the cooperative has a reputation of terminating the contracts as soon as the demand for special pigs falls. Therefore the standard producers may be reluctant to require that the cooperative terminates contracts with special producers when the demand for special pigs falls. These arguments suggest that the standard producers will leave a large part of the decisions regarding the production level of special pigs to the special producers.

5.4.3 Participation

The fixed bonus does not adjust the profit allocation between the producer groups when the demand changes. For example, a fall in the demand for special pigs, which weakens the outside opportunities for special producers, will not reduce the payment to the special producers. Hence, the standard producers may end up subsidizing the special producers when the demand for special pigs is low – and vice versa.

However, in the long run the bonus will probably be affected by changes in the relative profitability of different products, because the fixed bonus is subject to renegotiations.

5.4.4 Risk sharing

Changes in the world market price have the same effect for both standard and special producers. Hence there is full risk sharing regarding the world market price.

There is also full risk sharing regarding the price on the special market, because the bonus does not change if the demand for special pigs changes. However, if the demand for special pigs falls, the standard producers have an incentive to terminate some of the contracts on special pigs. This will expose the special producers to additional risk regarding the price on the special market.

5.4.5 Influence costs

There is no disagreement about the sale of special pigs when the bonuses to the special producers receive a fixed bonus.

However, there is a conflict concerning the production level. The standard producers have incentives to limit the production of special pigs until the marginal revenue of special pigs is equal to the world market price plus the bonus. The special producers prefer to produce until their marginal costs equal the bonus plus the base payment, i.e. the producer groups agree about the production level of special pigs only if the bonus is at the equilibrium level. In particular, if the bonus is to high the special producers will prefer a higher production level than the level preferred by the standard producers.

5.5 Fixed vs. Market-determined Bonus

In the table below we summarize the analysis of the market-determined and the fixed bonus systems. We evaluate the systems on five criteria: sales, production, participation, risk sharing and influence costs. The interpretation of the table is:

*** The criterion is satisfied
** The criterion is partly satisfied
* The criterion is not satisfied

Problem	Market-determined bonus	Fixed bonus
Sale	*	***
Production	**	**
Participation	**	*
Risk Sharing	*	***
Influence Costs	**	*

Table 5.5.1 Multi criteria evaluation of market-determined vs. fixed bonus

There is no distortion in the sales decisions when the special producers receive a fixed bonus. A market-determined bonus, on the other hand, distorts the sales since the standard producers will ration the sales in order to reduce the bonus payment to special producers.

The market-determined bonus causes adjustment in the production, when the demand for special pigs changes. As discussed above these adjustments only affect the level of excess production without removing the problem. Under the fixed bonus system changes in the demand for special pigs is only reflected in the production level through changes in the number of contracts.

The market-determined bonus system ensures that the special producers benefit from an increase in the demand for special pigs (as long as the utilization is between 57 and 100 percent). This means that the allocation of profit between the producer groups in the cooperative is likely to belong in the core.

The fixed bonus system provides good risk sharing between the producer groups. Under the market-determined bonus system the special producers bear most of the risk on the demand for special pigs.

Under the fixed bonus system the co-operative face large influence costs, because the standard producers will try to influence the management to terminate contracts with special producers when there is excess production of special pigs. The special producers oppose this. The market-determined bonus system gives no conflict about the level of the special production, because the total bonus payment depends only on the sale of special pigs (as long as the utilization of special pigs is between 57 and 100 percent). On the other hand there is internal conflicts about the sale of special pigs. Conflicts concerning the sales are probably easier to handle for the cooperative than conflicts concerning the production level, because decisions about the sale of special pigs do not directly involve changes in production practices at the farms. The conflict concerning the sale of special pigs will primarily affect the discussions about the cooperative's strategic marketing decisions, where the members traditionally play an active role.

From an economic point of view, the most important criteria are probably the sale and the production of special pigs. Furthermore the influence costs play a very important role in cooperatives, because influence activities can capture a large part of the members' and the management's time, cf. Hansmann (1996).

5.6 Change of Bonus System

Until January 2000, the NSL pigs were paid for by a fixed bonus of 1.10 DKr per kg. Now the producers receive a market-determined bonus varying between 0.80 DKr per kg. and 1.40 DKr per kg. In the following, we analyze how this change affected the cooperative. We assume that the market-determined bonus was designed such that the payment to the special producers, other things being equal, would be the same in both bonus systems.

If the cooperative sold the same quantity on the special market after the fixed bonus was replaced by the market-determined bonus, nothing would change. The bonus, the production, and the profit to each producer group would be the same. However, the standard producers have an additional option in the market-determined bonus system. They can reduce the bonus to the special producers by limiting the sale on the special market. The cost of doing this is that the revenue from the special pigs falls. Therefore, the majority will only reduce the sale until the marginal revenue on the special market equals the world market price plus the slope of the market-determined bonus (DKr 1.40). Reducing the sale on the special market reduces the bonus and thus the production. Hence, the production costs go down. These effects are illustrated in the figure below.

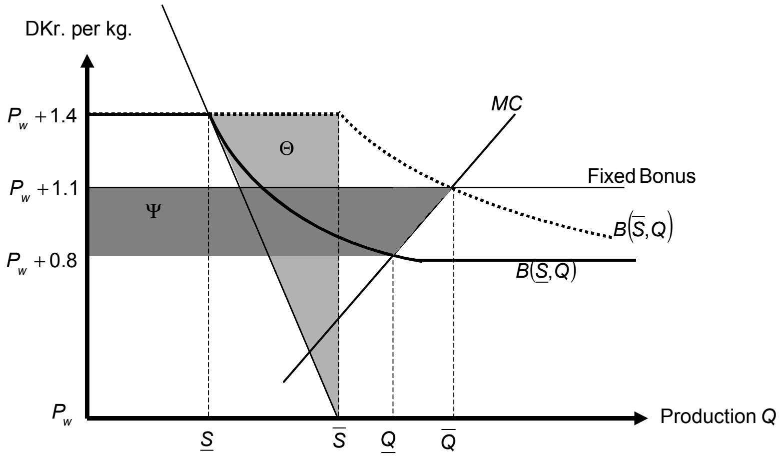

Figure 5.6.1 Changing from fixed to market-determined bonus

As illustrated in the figure, the standard producers gain by reducing the sale on the special market from $\overline{S}$ (the sale under the fixed bonus) to $\underline{S}$ (the sale under market-determined bonus). The gain is given by the amount saved on the bonus payment minus the decrease in revenue, i.e.

$$\Theta = 1.4(\overline{S} - \underline{S}) - [R(\overline{S}, \overline{Q}) - R(\underline{S}, \underline{Q})]$$

where $\overline{Q}$ and $\underline{Q}$ are the quantity produced under the fixed and the market-determined bonus, respectively.

The special producers lose when the payment scheme is changed from a fixed bonus to a market-determined bonus, because the bonus is reduced. The loss for the special producers is illustrated in Figure 5.6.1 as area Ψ.

The effect on the integrated profit of shifting from a fixed to a market-determined bonus system is the production cost savings minus the reduction in the sales revenue. This net effect can be either positive or negative, depending on the slope of the marginal cost and marginal revenue curves. The net effect is illustrated in the Figure 5.6.2.

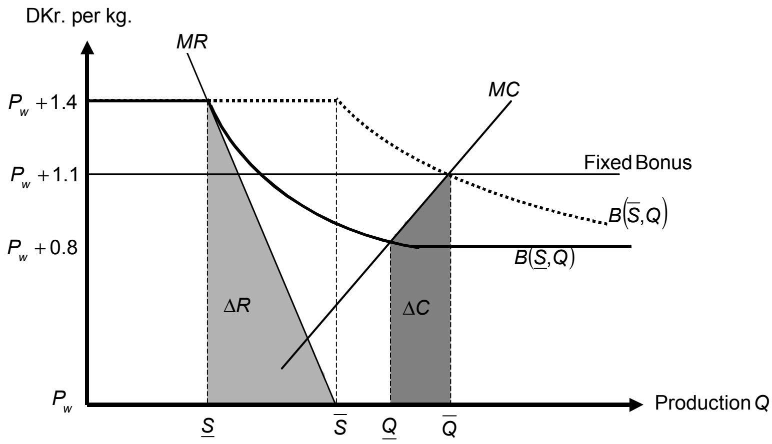

Figure 5.6.2 Net effect of replacing fixed bonus by market-determined bonus

5.7 Quantitative Analysis

The analysis above does not tell per se which bonus system generates the largest integrated profit. In this section we quantify the analysis, and estimate the gains and losses induced by replacing the fixed bonus with the market-determined bonus. We analyze the effect on two types of special pigs, Gourmet and Porker, two brands under the NSL program.

Danish Crown has provided weekly data for the period January 2000 – June 2001 on the delivered quantity of Gourmet and Porker pigs, the settlement prices, and the market-determined bonus. This enables us to compute the sale of special pigs.

We estimate the model described above where the standard producers determine the sale of special pigs, cf. Figure 5.6.2. We use the settlement price as a proxy for the world market price. The observations all belong to interval *II*, where the bonus is between 0.8 and 1.40 DKr per kg. Hence, the standard producers determine the sale of special pigs such that the marginal revenue on the special market is equal to the world market price plus DKr 1.4 per kg. The estimate of the marginal revenue is

$$MR = 15{,}17 - 2{,}43 \cdot 10^{-5} \cdot \mathrm{S}$$

According to this estimate the sale determined by the majority is $1.4/\left(2{,}43 \cdot 10^{-5}\right) = 57{,}510$ kg. per week smaller than the revenue maximizing sale (where $MR = P_w$). This leads to a reduction in the revenues of approximately DKr 40,000, which corresponds to 0.20 per kg. of special pig[17].

We also estimate the marginal cost curve in a linear regression model, estimating the production of special pigs as a function of the settlement price and the market-determined bonus. The result of the regression is

$$Q = 246{,}750 - 11{,}831 \cdot P_w + 82{,}842 \cdot \mathrm{B}$$

The results indicate that the production of special pigs is negatively correlated to the base price. This may seem counterintuitive. However, there are two explanations for this. First, the special producers can rather easily switch to production of standard pigs. Such a shift implies that the producer can increase his production since production of special pigs requires more space per pig than production of standard pigs. Shifting from special pigs to standard pigs is most profitable when the base price (= price for standard pigs) is high. The second possible explanation is that the regression shows an artificial correlation between the base price and the production of special pigs. The base price has been increasing through most of the period in the data set, while the special production has been decreasing. If the fall in the special production is caused by long-term trends, e.g. because the initial expectations about the demand for special pigs have proven too optimistic, the regression will show an artificial correlation.

Before the bonus system was changed, the bonus for special pigs was DKr 1.10 per kg. On average, the bonus has been DKr 0.97 per kg after the change. Hence, the bonus has fallen by DKr 0.13 per kg. According to the regression analysis this has reduced the production of special pigs by $0.14 \cdot 82{,}842 = 10{,}950$ kg. per week. This reduces the production costs by approximately DKr 11,000 per week.

Thus, according to our analysis, changing the bonus system has reduced the integrated profit by 40,000 - 11,000 = 29,000 DKr per week.

One should be careful in interpreting the results of our quantitative analysis. Our estimate for the cost of changing from a fixed bonus to a market-determined bonus system approximates an upper bound for the loss. There are three reasons for this.

Firstly, the special producers shifting to production of standard pigs obtain a profit from the new production. This profit is not incorporated in our calculations.

Secondly, there may of course be other explanations, not included in our analysis, for the decrease in the sale of special pigs. If the demand for special pigs has been falling during the period, e.g. due to less focus on animal welfare, the price effect on the demand for special pigs is overestimated in our analysis, because the world market price in general has been increasing during the period.

Thirdly, the long-term reaction to the reduction in the market-determined bonus is likely to be higher than the short-term adjustment we estimate. Hence, in the long

[17] The average payment (settlement price plus market-determined bonus) in the period was DKr 11.25 per kg.

run the reduction in the production costs is probably larger than our estimates suggest.

5.8 Conclusion

The farm-level differentiation is increasing in the Danish pig industry. In this chapter we analyze the contracts between special producers and Danish Crown.

The contracts are offered only to producers near the slaughterhouse processing the special pig in questions. These geographical restrictions ensure that the transport costs are minimized. In the long run the geographical restrictions will lead to heterogeneous dispersion of technology.

The producers of special pigs are compensated according to two different bonus systems, fixed bonus or market-determined bonus. In our analysis we assume that the standard producers, i.e. the majority in the cooperative, control the cooperative in a way that maximizes their profit – and not the integrated profit.

Both bonus systems lead to conflict of interest between the standard and the special producers. Under the fixed bonus, the conflict is concerning the production level of special pigs. Under market-determined bonus the conflict is concerning the sale of special pigs. Hence, changing from a fixed bonus to a market-determined bonus system shifts the internal conflict from one issue to another.

In January 2000, Danish Crown changed the bonus system for NSL pigs from a fixed bonus to a market-determined bonus. We have shown that this was beneficial for the standard producers, while the special producers became worse off. The total effect can be either positive or negative, depending on whether or not the distortion in the sale under the market-determined bonus is outweighed by reductions in the production costs.

Finally we quantify our analysis using weekly data for the last 18 months, in which the market-determined bonus has been used. Our analysis shows that the change in the bonus system has reduced the integrated profit by approximately DKr 30.000 per week. This corresponds to a loss of approximately DKr 0.15 per kg. of special pigs produced.

5.9 Appendix

The per kg. market-determined bonus can be formalized as follows

$$B(S,Q) = \max\left\{\gamma, \alpha\frac{S}{Q}\right\} = \begin{cases}\alpha S/Q & \text{if } Q < S\alpha/\gamma \\ \gamma & \text{if } Q \geq S\alpha/\gamma\end{cases}$$

When the standard producers (the majority of the cooperative) determine the quantity sold on the special market (S), they solve the following problem

$$\max_S\left[R(S,Q) - B(S,Q)Q;\ \text{ st. } Q \geq S\right] \Leftrightarrow \max_S\left[SP_s(S) + (Q-S)P_w - B(S,Q)Q;\ \text{ st. } Q \geq S\right]$$

The first order condition for this problem is

$$\underbrace{P_s(S)+\frac{\partial P_s(S)}{\partial S}S}_{=MR(S)}-P_w-\frac{\partial B(S,Q)}{S}Q=0$$

There are four possible solutions to the problem, corresponding to the intervals in Figure 5.3.1. The solutions are:

I. A corner solution $S=Q$ when $MR(S)-P_w-\alpha>0$.

II. An interior solution found when $Q<\frac{\alpha}{\gamma}S$. In this case the first order condition reduces to $MR(S)-P_w-\alpha=0$. We refer to this solution as $\underline{S}$.

III. An interior solution occurring when $\frac{\alpha}{\gamma}\underline{S}<Q=\frac{\alpha}{\gamma}S<\frac{\alpha}{\gamma}\overline{S}$. The solution is $S=\frac{\gamma}{\alpha}Q$. $\overline{S}$ is defined below.

IV. An interior solution occurring when $Q>\frac{\alpha}{\gamma}S$. The first order condition reduces to $MR(S)-P_w=0$. This is the revenue-maximizing solution, which we refer to as $\overline{S}$.

Hence, the standard producers determine the sale of special pigs as follows

$$S(Q)=\begin{cases} Q & \text{if } Q<\underline{\mathrm{S}} \\ \underline{S} & \text{if } Q<\underline{S}\alpha/\gamma \\ Q\gamma/\alpha & \text{if } \overline{S}\alpha/\gamma<Q<\underline{S}\alpha/\gamma \\ \overline{S} & \text{if } Q>\overline{S}\alpha/\gamma \end{cases}$$

Inserting $S(Q)$ into $\mathrm{B(S,Q)}$ gives us the following expression for the bonus per kg of special pig produced

$$B(S(Q),Q)=\begin{cases} \alpha & \text{if } Q<\underline{\mathrm{S}} \\ \frac{\underline{S}\alpha}{\gamma}\frac{1}{Q} & \text{if } Q<\underline{S}\alpha/\gamma \\ \gamma & \text{if } Q>\underline{S}\alpha/\gamma \end{cases}$$

We can now formalize the standard producers' problem of determining the optimal production level. The standard producers must pay the special producers the bonus plus the base payment, which we approximate by P_w. Hence, the standard producers solve

$$\max_Q[P_s(S(Q))\cdot S(Q)+P_w[Q-S(Q)]-B(S(Q),Q)Q-P_wQ]$$

The first order conditions in the four different intervals reveal whether or not the standard producers have an incentive to regulate the production level. The first order conditions are

I. $MR(S(Q)) - P_w - \alpha = 0$, this first order condition does not hold in interval *I*, since $MR(S) - P_w - \alpha > 0$. Hence, the standard producers want to increase the production of special pigs.

II. The production level influences neither the sale of special pigs nor the total bonus payment in this interval. Thus, the standard producers have no incentive to regulate the production in this interval.

III. $\frac{\gamma}{\alpha}\left[MR\left(\frac{\gamma}{\alpha}Q\right) - P_w - \alpha\right] = 0$. In interval *II* we have $MR(\underline{S}) - P_w - \alpha = 0$, since $\frac{\gamma}{\alpha}Q > \underline{S}$. In interval *III* we must have $MR\left(\frac{\gamma}{\alpha}Q\right) - P_w - \alpha < 0$ because $MR(\bullet)$ is a decreasing function. Hence, the first order condition for *Q* does not hold in interval *III*, and the standard producers have an incentive to reduce the production.

IV. $-\gamma = 0$, which does not hold if the special producers are guaranteed a positive minimum bonus. In such cases the standard producers want to reduce the production of special pigs.

CHAPTER 6.

The Practice of Contracting: Fact Sheets

Abstract

In this chapter we describe production contracts in eight different sectors of Danish agriculture. The contracts are described in fact sheets providing a systematic survey on how the contracts address different problems. The fact sheets are made in cooperation with the contract parties and have been approved by processors and producer organizations. Each fact sheet describes the main characteristics of the processor and the producers as well as the key aspects of the production and processing. Finally, the fact sheets describe the most important elements of the contracts, e.g. the allocation of obligations, the payment scheme, and the risk sharing.

6.1 Introduction

The practice of contracting contains valuable lessons acquired through many years of experience. The contracts are often just as advanced as recent progress in the contract theory. This suggests that both practitioners and researchers can learn from the practice of contracting.

We have studied contracts representing a broad range of the agricultural sectors in Denmark. The contracts cover different ownership structures. Some contracts illustrate the problems of introducing contract production in cooperatives with heterogeneous producer groups. Other contracts illustrate the conflicts between producers and investor-owned firms in the food industry.

The contracts we have studied cover the following sectors:

- ***Peas:*** contracts between producers of consumption (green) peas and the investor-owned Danisco Foods. The contracts facilitate precise coordination and provide risk-sharing through relative performance evaluation.
- ***Special Pigs:*** contracts between Denmark's largest slaughterhouse, Danish Crown, and producers of special pigs (e.g. UK pigs, free range pigs and organic pigs). Danish Crown is a cooperative and the contracts reflect some of the difficulties in contracting with different producer groups within a cooperative.

- ***Eggs*:** contracts between the cooperative Danæg and producers of battery eggs, deep litter eggs, free-range eggs and organic eggs, respectively. The contracts coordinate the combating of disease at the different levels of production.
- ***Broilers*:** contracts between private producers and the investor-owned Rose Poultry. The contracts ensure a high level of food safety through the tight control of inputs.
- ***Fruit*:** contracts between producers of blackcurrants and cherries and the investor-owned processor Vallø Saft. The contracts facilitate both coordination and usage of local information in the harvest process.
- ***Grass and Clover Seed*:** contracts between producers and the three major processors in the industry: DLF Trifolium (a producer-owned cooperative), Hunsballe Frø (owned by a private foundation), and the investor-owned Wibollt. The contracts are very similar. However, some of the contract details reflect the differences in ownership structures.
- ***Sugar Beet*:** contracts between producers and the investor-owned Danisco Sugar. The production of sugar is highly regulated in the EC. The producers have non-tradable production quotas.
- ***Potatoes*:** contracts between producers of potatoes and their cooperative AKV Langholt. The potatoes are processed into starch. The total quantity is regulated through tradable production rights.

In the following we describe these contractual relationships in further detail.

6.2 Peas for Danisco Foods A/S[1]

6.2.1 The processor

Core business
Danisco Foods[2] processed vegetables etc. for deep freezing. The peas were sold in mixes of frozen vegetables. The supermarket chains used their private labels.

Contracts
A standard contract was used for production of consumption peas (green peas). Furthermore Danisco Foods had contracts for the production of carrots, leeks, onions and celery.

Size
Danisco Foods had approximately 1200 employees. The total area under contract was 4550 ha. of which 4100 ha. were used for production of peas.

Danisco Foods was the only processor of peas in Denmark. Foreign competitors were selling on the Danish market. Danisco Foods exported 60 percent of its production.

Ownership
Danisco Foods A/S was a subsidiary company, 100 percent owned by Danisco A/S, which is quoted on the Copenhagen Stock Exchange. The largest shareholders in Danisco A/S[3] are three pension funds owning about 25% of the shares (ATP, PFA Pension and LD).

6.2.2 The producers

Total production
In 1999 there were 240 producers growing peas for Danisco Foods. The producers were organized in the Pea Growers' Association, which participated in the settlement of conflicts and the negotiation of the contract. The total area used for production of peas for Danisco Foods was 4100 ha. This means that the producers on average used approximately 17 ha. for the production of peas.

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[1] In September 2000 the Belgian company Ardo bought Danisco Foods A/S[1]. The production of peas for consumption continues under the name of Ardofreeze at one of Danisco Foods' two factories. This fact sheet is based on the situation before Danisco Foods was sold.
[2] The primary sources for this fact sheet are: Christian Stigaard Sørensen (1998), Pea Growers' Association (1998), and Danisco Foods (1997, 1998).
[3] A/S is the Danish equivalent for Ltd.

Specialization
Over the years the producers used on average 15 percent of their land for pea production. Some producers used almost all their land for pea production in one year, but did not grow peas in the following years. Danisco Foods required that no leguminous plants had been grown on the area during the previous 5 years.

6.2.3 Production and processing

Timing is crucial in the production of peas. The peas must be harvested within 24 hours. If the peas are harvested too late the taste will be ruined, because the peas will be over ripe, so that they cannot be used for consumption. If the peas are harvested too soon, the yield will be too low. When harvested the peas must be frozen within 4 hours to remain fresh. Efficient use of factory capacity, the harvesting machines, etc. requires precise coordination. Danisco Foods did the harvesting using specialized machines.

6.2.4 Contract details

Selection of producers
Producers who were interested in contract production contacted Danisco Foods. Danisco Foods selected their producers taking into consideration the planning of the harvesting route, the quality of the soil, etc. In general Danisco Foods preferred few but large fields. Producers automatically became members of The Pea Growers' Association. The minimum area for contracting was 10 ha. The standard yield and the capacity of the factory determined the total area under contract.

Duration
Most producers engaged in one-year contract relationships due to crop rotation. Some of the producers could not grow peas every year because, as explained above, Danisco Foods required that areas used for pea production should not have been used for the production of leguminous plants within the previous 5 years. Some producers effectively entered a long-term contractual relationship, since they had their contracts renewed from year to year.

The processor's tasks
- Determine the production plan (who grows what and when).
- Deliver the seeds.
- Inspect the production areas and advice before and during the growing season.
- Harvest the peas.
- Process the peas and sell the products.

The producer's tasks

- Supply production areas.
- Do the sowing.
- Keep a log of the production.
- Do all crop work until harvest.

Enforcement and monitoring

Danisco Foods inspected the production area

- Before the parties signed the contract.
- During the growing season.
- When producers contacted Danisco Foods because of weed or vermin problems.
- Immediately before harvest (samples were taken).

An arbitrator settled disputes arising out of the contract.

Payment

The payment was determined in two steps. First the payment at factory level, i.e. the total amount Danisco Foods must pay the producers, was determined. Danisco Foods paid DKr 1.40 per kg. for the first 5500 kg. per hectare and DKr 0.55 per kg. for the remaining quantity per hectare. The producers were guaranteed a minimum of DKr 4800 per hectare. The payment at factory level can be illustrated like this:

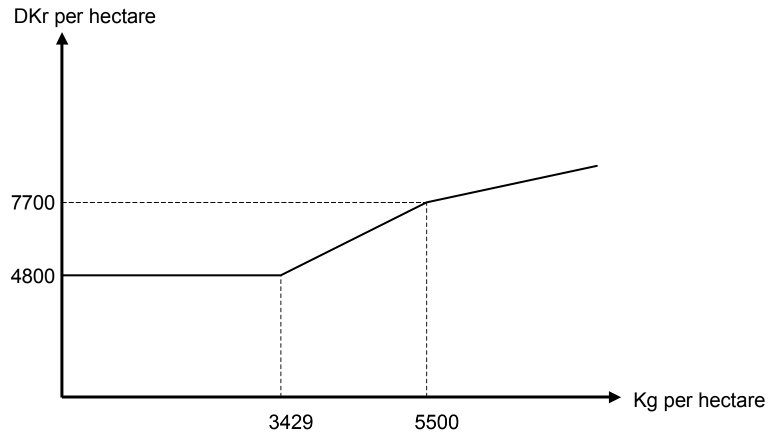

Figure 6.2.1 The factory payment[4]

In the second step the factory payment was allocated to the individual producers. The producers were divided into groups according to the variety sown and the time

[4] Danisco Foods (1998).

of sowing. This meant that producers in the same group had the same growing conditions. The average payment was the same for all groups. Within each group the total payment was shared in proportion to the producers' production. And, with a minimum payment of DKr 4800 per hectare, the individual producer was facing a linear price scheme[5]. The following figure shows the payment scheme for a producer in three different groups, given an average production at factory level of 7500 kg. per hectare.

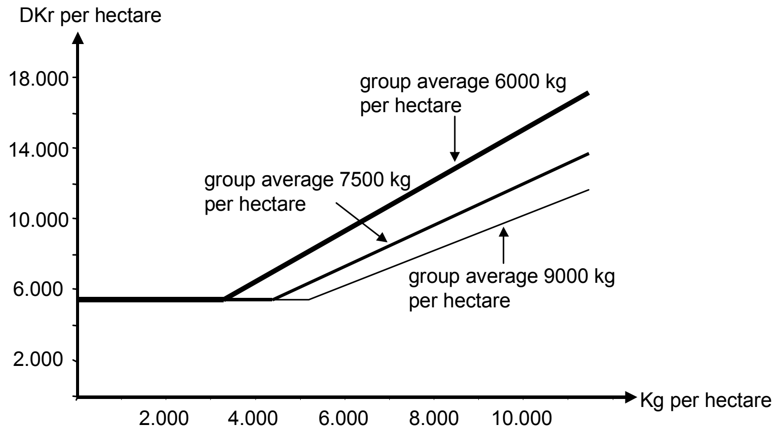

Figure 6.2.2 The payment to a producer[6]

Example of a payment[7]

In 1998 the average yield was 6337 kg. per hectare. Hence, the factory payment was:

Price	Unit price, DKr/kg	Quantity, kg/hectare	Payment, DKr/hectare
High price	1.40	5500	7700.00
Low price	0.55	837	460.35
Total		**6337**	**8160.35**

Table 6.2.1 Factory payment in 1998

The payment to an actual producer was determined as follows:

Average yield in group	6950	kg/hectare

[5] In this graph the effect of an increase in the production of one producer on the total factory payment and on the average production in his group is not included.
[6] Danisco Foods (1998).
[7] Danisco Foods (1998b).

Unit price	8160.35/6950	1.17	DKr/kg
Producer's total delivery (from 10 hectares)		74,920	kg
Total payment to producer	1.17 x 74,920	**87.968**	**DKr**

Table 6.2.2 Producer payment

Risk and insurance

General production risk
The General production risk (for example, from weather conditions) was in part borne by the producers because the payment (the factory payment) to the producers was less in years with a poor harvest. The producers were, however, guaranteed a minimum payment.

Specific production risk
In case of a poor harvest on an individual farm, the producer only bore the loss down to a minimum payment of DKr 4800 per hectare. Furthermore the division into groups gave a certain risk sharing because a low yield from a producer decreased the average yield in his group and thereby increased the price per kg.

Price risk
The producers were guaranteed a fixed price i.e. Danisco Foods bore the entire price risk.

Other risk
The payment to the individual producer was highly dependent on the production of the other producers in his group. This meant that the division into groups by itself put some risk on the producers (i.e. group composition risk).

6.3 Special Pigs for Danish Crown

6.3.1 The processor

Core business
Danish Crown[8] slaughters, processes, and sells pigs and beef cattle. Furthermore, Danish Crown provides food services, and delicatessen and sausage products.

Contracts
Most members of the cooperative deliver standard pigs. In addition contracts are offered for the production of the following special pigs:

- UK Pigs: This production is adapted to the UK legislation on animal welfare.
- Italian Pigs: Special pigs targeted at the Italian market, especially emphasizing traceability.
- EU heavyweight pigs: This special pig is primarily targeted at the German market for fresh meat.
- Male Pigs (boars): Castrating the pigs is not allowed in this special production.
- National Specialty Label [NSL], (e.g. Gourmet and Porker): was originally introduced by the Danish Ministry of Food. These special pigs are targeted at the domestic market.
- Organic Pigs: This special production follows the official rules for organic food production.
- Free Range Pigs: Special production especially emphasizing animal welfare.

Organic and Free Range Pigs are produced for Friland Food A/S.

The production of special pigs is quantitatively and geographically restricted by contracts. In the production of standard pigs there are no quantitative restrictions (free delivery). The members of the cooperative are obligated to deliver at least 85 percent of their weekly production to Danish Crown. Membership can be terminated with 1 year's notice.

Size
Danish Crown has a turnover of approximately DKr 37 billion and has 19,800 employees (2000). Each year the producers deliver 16 million pigs and 400,000 head of cattle to Danish Crown. Danish Crown has a market share of approximately 78 percent and 60 percent of the Danish pig and cattle slaughtering, respectively. The three cooperatives Danish Crown, Steff Houlberg, and Tican handle 97 percent of

8 The primary sources for this fact sheet are: Danish Crown (1999a-e, 2000a-c, 2001a-c), Friland Food (1999a,b), and Martin Villadsen and Anders Andersen(1999).

pig slaughtering in Denmark. Around 80 percent of the Danish pig production is exported.

Ownership
Danish Crown was founded in 1990 through the merger between Tulip Slagterierne (Tulip Slaughterhouses), Slagteriselskabet Wenbo (Wenbo Slaughterhouse), and Østjyske Slagterier (East Jutland Slaughterhouses). In 1998 the two biggest slaughterhouses in Denmark, Danish Crown and Vestjyske Slagterier (West Jutland Slaughterhouses), merged. Danish Crown is a cooperative owned by approximately 22.000 members. Friland Food A/S owned by Friland Food Holding A/S (40%) and Danish Crown (60%), handles part of Danish Crown's contract production (Organic and Free Range Pigs).

6.3.2 The producers

Total production
In 1999/2000 there were 12,368 pig producers delivering to Danish Crown. The total delivery of slaughter pigs was approximately 15.2 million. This means that the average production for a Danish Crown producer was approximately 1,226 pigs in 1999/2000. Less than 5 percent of the producers produce more than 30 percent of the total production. Each of these producers produces more than 5,000 pigs per year.

Almost 20 percent of the number of total pigs slaughtered are special pigs (1999/2000).

Special pig	Share of total pig slaughtering
UK	12.0%
Italian	1.2%
EU heavyweight pigs	4.3%
National Specialty Label	1.0%

Table 6.3.1 Special pigs share of total pig Slaughtering[9]

Specialization
Most of the producers only produce one kind of slaughter pig on their farms (e.g. standard pigs or UK Pigs), since in general it is impossible to contract for special pigs and other types of slaughter pigs at the same time. There is an exception in the contracts for EU heavyweight pigs where a producer can sell part of his production as EU heavyweight pigs and the rest as standard pigs.

[9] Martin Villadsen and Anders Andersen (1999).

Around 90 percent of the pig producers have pig production as their primary source of income rather than arable and other animal production. However, all the pig producers have some arable production, since environmental laws require there to be a balance between the size of a producer's livestock production and the size of his farming area. Producers classified primarily as pig producers[10] have on average 75.6 ha. of land[11].

6.3.3 Production and processing

The production of pigs is predominantly organized in one of two ways. Some producers handle the entire production process, i.e. from the rearing of piglets to the finishing of the pigs. In contrast, some specialized independent producers handle only a part of the production. One producer will handle the production of piglets and sell them to another producer, who then handles the finishing of the pigs. Of course, some producers choose a hybrid of the two systems. A producer of piglets may finish some of the pigs himself and sells the rest as piglets.

In Denmark approximately 50 percent of the pig producers do not produce piglets, 10 percent of the producers only produce piglets, while 40 percent of the producers both produce piglets and finish the pigs. Producers buying the piglets finish almost 50 percent of the pigs. Producers only selling piglets produce approximately 30 percent of the piglets[12].

Most of the restrictions in special production concern the production of piglets. However, the incentives in the contracts for special production are primarily directed towards the pig producer.

6.3.4 Contract details

Selection of producers

All pig producers can become members of the Danish Crown cooperative. Contract production calls for fulfillment of the requirements for the special production in question. Furthermore, most of contract production is geographically limited (relating to the distance between the producer and the slaughterhouse that process the product in question). Producers delivering Organic Pigs must be licensed by The Ministry of Food. To deliver Free Range Pigs there is a requirement that the producer shall have a minimum nominal shareholding of DKr 5,000 (1998) in Friland Food Holding. If there is no excess production of Free Range Pigs, all producers can deliver Free Range Pigs.

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[10] I.e. producers receiving at least 2/3 of their income from pig production and at most 1/3 from vegetable production and other animal production.
[11] Calculations based on SJFI (1999).
[12] SJFI (1999).

Duration

In general the contracts are in force until one party gives notice of termination. Breach of contract results in its immediate termination. The notice of termination varies according to the type of contract.

- UK Pigs: Notice of termination is 3 months. The contract is terminated if the producer of slaughter pigs changes the supplier of piglets, unless the new supplier of piglets fulfills the requirements for the production of UK Pigs.
- EU heavyweight pigs: Notice of termination is 6 weeks.
- Male Pigs (boars): Notice of termination is 6 months.
- Gourmet and Porker: Normally the notice of termination is 6 months. Terminating contracts is sometimes used to control quantity. The notice of termination is reduced to 6 weeks if there are significant deviations from standard supply conditions (e.g. the quantity, average weight or meat-percentage of the pigs supplied).
- Organic Pigs and Free Range Pigs: Notice of termination is 12 months for the company and 6 months for the producer.

The processor's tasks

- Buy all pigs delivered by the producers (The pigs delivered under contract receive a bonus, pigs not fulfilling the requirements in the contract are settled as standard pigs).
- Provide advice.
- Transport the pigs to the slaughterhouse.
- Processing.
- Sale.

The producer's tasks

- Buy feed from a supplier approved by Danish Crown.
- Produce pigs. The producer owns the pigs and the buildings and supplies the labor and other inputs.
- Fulfill requirements for the special production in question:
  - UK Pigs: untethered keeping of sows from weaning until seven days before farrowing.
  - Italian Pigs: Restrictions on feed, traceability.
  - EU heavyweight pigs: The pigs must have a meat-percentage above 58%. On average the pigs must weigh at least 83 kg.
  - Male Pigs (boars): No castration.

- NSL: The pigs must have 30 percent more space than Danish legislation requires. Slatted floors not allowed in the resting area. Litter required in the resting areas.
- Organic Pigs: Sows on grass for a minimum 150 days in the summer. The pigs must have access to an outdoor area. Minimum 75 percent of the feed must be organic. Slatted floor not allowed in the resting area. Litter in the resting area.
- Free Range Pigs: Loose stalls. Outdoor farrowing huts. Slatted floors not allowed in the resting area. Litter in the resting area.

- Self-monitoring to document the observance of the requirements for the production in question.
- Delivery of the entire production to Danish Crown.

Enforcement and monitoring

Danish Crown inspects the producer before entering into a contract, and thereafter once a year. Production is also monitored by the taking of random samples by the District Veterinary Inspector, the Society for the Protection of Animals, the Agricultural Advice Center and customers in the UK and Italy who all perform spot checks. Friland Food can inspect the production of Free Range Pigs at any time. An arbitrator settles disputes arising out of the contracts.

Payment

All the producers are paid Danish Crown's price quotation for pigs.

In addition to the price quotation the standard producers are paid according to two quality parameters: slaughter-weight and meat-percentage.

- Slaughter-weight: for each kg. the slaughter-weight exceeds the maximum slaughter-weight (80.9 kg), the price is reduced by DKr 0.10. For each kg. the slaughter-weight is below the minimum slaughter-weight (67.0 kg), the price is reduced by DKr 0.10. The price reduction is capped at DKr 1.00.
- Meat-percentage: for each percent point the meat-percentage exceed 59 percent, the price is increased by DKr 0.10 per kg. When the meat-percentage is below 59 percent, the price is reduced by DKr 0.10 per kg. per percent point.

In addition to this standard payment scheme different bonuses are paid. Danish Crown pay bonuses according to two main principles: fixed bonuses and market-determined bonuses (dependent on the share of special production actually sold on the special market).

Fixed bonuses are used for:

- UK Pigs: DKr 0.40 per kg
- Male Pigs: Deduction of DKr 2 per kg. that is rejected due to excess levels of skatol (same payment as for a standard boar). To cover analysis costs there is a deduction of DKr 25 per pig for all Male Pigs. About 2 percent of the Male Pigs are rejected for fresh meat consumption due to high levels of skatol and are instead used for processed meat products.
- EU heavyweight pigs (No male pigs):

Weight in kg	Reduction, DKr/kg
83-99.9	4 % of Danish Crown's Price Quotation
100-109.9	1.20
110-	Sows/Overweight

Table 6.3.2 Deduction for weight[13]

Note that the price reduction in table 2 for overweight of an EU heavyweight pig is less than the standard price reduction for overweight. The price reduction for low meat-percentage (below 56 percent) for EU heavyweight pigs is more than the standard price reduction for low meat-percentage.

Meat-percentage	Bonus, DKr/kg. per percentage point
59-65.0%	0.10
56-58.9%	-0.10
48-55.9%	-0.15

Table 6.3.3 Bonus for meat-percentage[14]

Market-determined bonuses are used for:

- NSL-Pigs: The bonus is only paid for pigs with a meat-percentage of at least 57.0% and a slaughter-weight in the interval 80-93.9 kg. Finally, no NSL bonus is paid if the pig has cut away parts. The NSL bonus is between DKr 0.80 and 1.40. The bonus depends on the share of NSL pigs that are actually sold on the special market as described in Table 4.

[13] Danish Crown (1999b).
[14] Danish Crown (1999b).

Percentage of special pigs sold on special markets	NSL-bonus, DKr/kg
100%	1.40
90%	1.26
80%	1.12
70%	0.98
60%	0.84
50%	0.80

Table 6.3.4 The market-determined bonus[15]

- Free Range Pigs: The free range bonus for slaughter-weights in the range from 77.0 to 79.9 kg. is DKr 0.50 per kg. and in the range from 80 to 91.9 kg. it is DKr 1.40 per kg. There is no deduction for overweight in the range from 77.0 kg. to 88.9 kg. In the range from 89.0 kg. to 91.1 kg. there is the standard reduction in the price.

Weight in kg	Bonus, DKr/kg	Overweight deduction DKr/kg
77-79.9	0.50	0
80-88.9	1.40	0
89-91.9	1.40	0.90-1.00

Table 6.3.5 Free range bonus[16]

Furthermore, DKr 14 is paid for each 30 kg. piglet resulting in an approved Free Range pig.

A combination of market-determined bonuses and fixed bonuses is used for:

- Organic Pigs: A monthly bonus between DKr 0 and 3 per kg. is paid. The size of this bonus depends on the supply and demand for Organic Pigs (market-determined bonus). In addition, the producers receive an organic bonus of DKr 5.50 per kg. for approved pigs and DKr 3 per kg. for non-approved. The Organic Pigs are only approved if their slaughter-weight is between 74.0 kg. and 91.9 kg. The meat-percentage must be at least 56.0 for the entire pig and at least 59 percent on the middle part of the pig. Furthermore the fat layer on the back must be between 10 and 22 mm. Finally, pigs with cut away parts are not approved.

[15] Danish Crown (2000c).
[16] Friland Food (1999a).

Example of payment for NSL pigs:

7 NSL pigs were delivered[17]. 2 pigs qualified for the NSL bonus, which requires a meat-percentage of at least 57.0%, a slaughter-weight in the range from 80 to 93.9 kg. and no cut away parts. Danish Crown's price quotation was DKr 10.30 per kg.

Weight Kg	Meat-percentage %	Bonus for meat-% DKr/kg	NSL bonus DKr/kg	Deduction for markings DKr/kg	Price per kg DKr/kg	Payment DKr
68.5	61.3	0.23	0	-0.53	10.00	685.00
78.1	58.7	-0.03	0	0	10.27	802.09
81.7	64.4	0.54	1.00	0	11.84	967.33
89.6	62.9	0.39	No, due to cut away parts	0	10.69	957.82
91.3	62.1	0.31	1.00	0	11.61	1,059.99
94.8	60.0	0.10	0	0	10.40	985.92
100.6	57.7	-0.13	0	0	10.17	1,023.10
684.9						**6,481.25**

Table 6.3.6 Example of payment for 7 NSL pigs

Example of payment for UK pigs:

In this example[18] 5 UK Pigs were delivered. 2 pigs qualified for the UK bonus, which requires that the slaughter-weight is in the range from 67.0 to 80.9 kg. Furthermore, the meat-percentage must be at least 58%. Danish Crown's price quotation was DKr 10.30 per kg.

Weight Kg	Meat-percentage %	Bonus for meat-% DKr/kg	UK bonus and slaughter-weight reduction DKr/kg	Deduction for markings DKr/kg	Price per kg DKr/kg	Payment DKr
63.9	61.6	0.26	-0.40	0	10.16	649.22
69.1	59.7	0.07	0.30	0	10.67	737.30
73.4	55.8	-0.32	0	0	9.98	732.53
76.0	61.2	0.22	0.30	-0.54	10.28	781.28
80.8	54.9	-0.41	0	0	9.89	799.11
363.2						**3,699.44**

Table 6.3.7 Example of payment for 5 UK pigs

[17] The example is based on an actual payment from Danish Crown to a producer (Danish Crown, 2001a).
[18] The example is based on an actual payment from Danish Crown to a producer (Danish Crown, 2001c).

Example of payment for organic pigs:

In this example[19] six organic pigs were delivered. Only two of the pigs were approved as Organic Pigs. The pigs not approved as Organic Pigs were rejected due to:

- Low slaughter-weight, below 74.0 kg. (2 pigs).
- Low meat-percentage, below 56 percent (1 pig).
- Meat-percentage in mid part of pig below 59% or fat layer on the back not between 10 and 22 mm. (1 pig).

Danish Crown's price quotation is DKr 10.10 per kg.

Weight Kg	Meat-percentage %	Bonus for meat-% DKr/kg	UK bonus and slaughter-weight reduction DKr/kg	Deduction for markings DKr/kg	Price per kg DKr/kg	Total payment DKr
66.2	59.3	0.03	-0.10	0	10.03	663.99
71.5	54.7	-0.43	0	-0.48	9.19	657.09
75.0 [A]	57.5	-0.15	0	0	9.95	746.25
75.3 [A]	59.5	0.05	0	0	10.15	764.30
82.0	55.8	-0.32	0	-0.49	9.29	761.78
88.7	57.9	-0.11	-0.80	0	9.19	815.15
458.7						4,408.56
Organic bonus payment:						
Approved (A)		$150.3\,\text{kg} \times 5.50\,DKr/kg$				826.64
Non-approved		$308.4\,\text{kg} \times 3.00\,DKr/kg$				925.20
Sub Total						1,751.84
Total						**6,160.40**

Table 6.3.8 Example of payment for 6 Organic pigs

[19] The example is based on an actual payment from Danish Crown to a producer (Danish Crown, 2001b).

Risk and insurance

General production risk
The general production risk is borne by the producers.

Specific production risk
If the production fails for an individual producer, he bears the loss himself.

Price risk
The price risk related to special products is borne by all the members in the cooperative. This price risk is the variations in the price premium for special products. Neither the market-determined bonuses nor the fixed bonuses depend on the price premiums for special products. This means that a reduction in the price premium for the special products lowers the payment to all members of the cooperative.

Other risk
When the producers receive a fixed bonus, Danish Crown is obligated to pay bonuses for all the special pigs produced, regardless of whether the meat can be sold as special pig-meat or not. Hence Danish Crown, and thereby all the members, bears part of the risk of fluctuations in demand. When the market-determined bonuses exceed the minimum level, Danish Crown is in reality only paying bonuses for the special pigs actually sold on the special market[20]. Thus, the producers of the special pigs bear part of the risk of fluctuations in demand.

[20] The total bonus payment is given by:

$$1.4\ \text{DKr/kg}\ \frac{\text{Quantity sold as specialty hogs}}{\text{quantity produced}} \times \text{quantity produced} = 1.4\text{DKr/kg.} \times \text{Quantity sold as specialty hogs}$$

6.4 Eggs for Danæg

6.4.1 The processor

Core business
The processor, Danæg[21] receives and processes eggs into consumer eggs and egg products. Their egg products are consumer eggs, semi-manufactured products such as pasteurized egg yolks, and ready-made dishes.

Danæg processes four types of eggs. The egg types have different requirements regarding lighting, indoor and outdoor space, etc. for the hens. The four types are:

- Battery eggs: Hens are kept in a battery system.
- Deep litter eggs: Hens can walk around within the hen-house (no battery system).
- Free range eggs: Hens can walk around within the hen-house (no battery system) and have access to outdoor space.
- Organic eggs: Hens can walk around within the hen-house (no battery system) and have access to outdoor space. Moreover, the use of organic feed is required and there is a maximum size of flock.

Contracts
A producer is required to deliver his entire production of eggs to Danæg. Danæg and the producer sign a new contract for each new stock of hens. Danæg can only refuse to sign a new contract if conditions for delivery are not satisfied.

Size
Danæg has a turnover of approximately DKr 383 million (1999). Danæg, including subsidiary companies, has 210 employees. Danæg is the largest supplier of consumer eggs in Denmark. Danæg processes 60 percent of the authorized egg production in Denmark. Danæg exports approximately 16 percent of its production[22].

Ownership
Danæg Amba is a producer-owned cooperative. Delivery of eggs to Danæg automatically implies membership of the cooperative. Danæg Amba owns 100 % of Danæg A/S[23] and Dan-Chick Handel A/S and 92% of Danæg Products A/S. Danæg also owns parts of several companies established for the purposes of international cooperation.

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[21] The primary sources for this fact sheet are: Danæg (2000a-d, 2001a,b) and Lars H. Thomsen, Divison Manager Danæg, Christiansfeldt, personal communication, 2001.
[22] S. Jensen, Roskilde, CEO Danæg, Roskilde, personal communication, 2001.
[23] A/S is the Danish equivalent to Ltd.

6.4.2 The producers

Total production

28,586 tons of eggs were delivered to Danæg in 1999. Approximately 100 active members produce consumer eggs for Danæg. The producers are categorized in Table 1 below.

	Battery Eggs	Deep Litter Eggs	Free Range Eggs	Organic Eggs
Number of producers	47	36	15	18
Number of flocks	83	49	24	22
Total number of hens	1,345,760	302,210	150,672	148,521
Average number of hens per producer	28,633	8,635	10,045	8,251
Average number of hens per flock	16,214	6,168	6,278	6,751

Table 6.4.1 The egg producers[24]

Specialization

The producers specialize in egg production. However, the producers have some arable production as well. Producers cannot have more than one type of egg production, unless the eggs have a different shell color. Thus, most of the producers only produce one type of egg (e.g. battery eggs).

6.4.3 Production and processing

The egg industry is highly specialized. A producer often manages only one of the following processes: production of breeding animals, production of hatch eggs, hatchery, breeding of production animals, and production of consumer eggs. The specialization reduces the danger of infection in production.

It takes 2-3 weeks to hatch out eggs and 20 weeks for day-old chicks to become egg-laying hens. The hens must be slaughtered before they are 80 weeks old.

Food safety is very important in the egg industry because of the dangers of salmonella and campylobactor infections. Poultry producers, including egg producers, are subject to the government's plan of action on salmonella. The contracts also follow the poultry industry's voluntary plan of action on salmonella. All levels of the production process focus on the prevention, detection and combat of infections, so that the risk of infection is minimized for hens and consumers

[24] Danæg (2001a).

The prevention and combat of salmonella is systematic. It involves reducing the danger of infection through:

- Feeding requirements.
- Frequent egg collection.
- Hygiene regulations, including procedures at all levels of the production, such as restrictions on the design of buildings, basic hygiene in hen-houses and egg rooms, detailed requirements for the collection, storage and transport of eggs. Danæg also heat disinfect their transport packing and containers with microwaves.
- When collected, the eggs are kept at 8-12º C until they reach the consumers (special Danæg requirement).
- Regular testing for salmonella at all levels of the production. Test materials are eggs, chicks, hens, blood, manure and dust. For instance, every 9th week the production of consumer eggs is tested (manure and eggs, both Elisa blood test and bacteriological test. Danæg is the only egg-processing company in the world performing both tests).
- Eggs from salmonella-infected flocks are heat-treated and cannot be sold as whole eggs.
- Breeding animals cannot have been treated with antibiotics. If salmonella is detected among the animals, the flock will be slaughtered.
- Vaccinations are not allowed at any of the production levels.

The processing at the Danæg factory starts with quick manual sorting. The rest of the processing is highly mechanized. Special ultraviolet light reduces the numbers of bacteria on the surface of the eggs. Machines remove eggs with broken shell and eggs containing blood. The eggs are also weighed and packed by machines.

6.4.4 Contract details

Selection of producers

Only producers of consumer eggs can become members of Danæg. The board of directors must approve the membership. If production facilities are sold, the new owner can take over the membership and the current delivery contracts.

Duration

The contract must be signed 6 months before the delivery of eggs begins. The contract can be terminated with one year's notice to the first of January. If one party breaches the contract, the other party can terminate the contract without notice.

The processor's tasks

- Approve rooms for storage and packing.

- Determine whether the contracted starting time for egg production should be changed.
- Ensure supply of 16-17 week old chickens to the producers of consumer eggs.
- Give advice on production.
- Perform salmonella test screening of consumer egg production every 9th week (manure and eggs, both Elisa blood test and bacteriological test).
- Receive all the eggs from the contracted number of hens.
- In case of excess production, require a part of the flock to be slaughtered.
- Collect the eggs from the producers (min. twice a week from each producer).
- Disinfect area for loading truck and truck driver.
- Heat disinfect transport packing and containers.
- Perform test screening of the eggs (flavor and color of egg yolk).
- Processing and sale.

The producer's tasks

- Select breeding strain.
- Keep the contracted number of hens. The hens must be bought through Danæg which guarantees that the hens are free of Salmonella.
- Observe hygiene regulations and requirements, the government and the voluntary plans of action on salmonella, plus the legislation on salmonella.
- Use feed free of salmonella – heat-treated to 82º C.
- Collect eggs every day and cool the eggs the same day. Sort the eggs into:
  - First-rate eggs:
    - Non-cracked eggs without egg yolk, dirt, blood or manure on the egg shell.
  - Sorted out eggs:
    - Washed non-cracked eggs.
    - Cracked eggs.
  - Non-deliverable eggs:
    - Wind-eggs.
    - Eggs with a porous shell.
    - Eggs with a hole in the egg shell larger than 5 mm in diameter.
    - Eggs with a broken shell membrane.
    - Eggs with manure, egg yolk, blood or other foreign objects on the eggs.

- Store eggs in a cool storage room (8-12º C). Egg containers must be stored in a cool storage room protected against humidity, dust and vermin.
- Deliver eggs regularly.
- Slaughter the hens before they are 80 weeks old.

Enforcement and monitoring

Danæg performs preliminary inspections of the production facilities (e.g. cool storage room and packing room). Every 9th week during the production Danæg performs a salmonella test. On collection, the truck driver monitors the temperature in the cool storage room.

The Maritime and Commercial Court in Copenhagen settles disputes.

Payment

The payment to a producer for a first-rate egg depends on the type and size of the egg, cf. Table 2. The producer receives a lower price for cracked and washed eggs. However, the reduction in price is less if the producer sorts the eggs out instead of Danæg sorting them out. There is a reduction in the payment for eggs containing blood and discarded eggs[25].

	Battery Eggs	Deep Litter Eggs	Free Range Eggs	Organic Eggs
XL	0.40	0.40	0.40	0.85
L	0.50	0.74	0.80	1.16
M	0.48	0.69	0.76	1.06
S	0.26	0.26	0.26	0.30
<50 gr.	0.18	0.18	0.18	0.18

Table 6.4.2 Payment for first-rate eggs (DKr per egg)

Eggs less than 50 gr. are not quality sorted. The rest of the eggs are sorted and paid for according to Table 3 below.

	Sorted by Producer	Sorted by Danæg
Cracked	+0.20	+0.10
Washed	+0.20	+0.10
Eggs containing blood	-0.08	-0.08
Discarded eggs	-0.08	-0.08

Table 6.4.3 Payment for sorted eggs (DKr per egg)

[25] Danæg (2001a).

Danæg also uses a quantity reduction as shown in Table 4 below.

Number of Hens	Reduction
0-3,000	0.005
3,000-7,500	0.003
7,500-20,000	0.002

Table 6.4.4 Quantity reductions (DKr per egg)

The proportion of eggs sized L and M that Danæg cannot sell to retailers, is paid for at a reduced price. The reduction is the difference between the price for eggs sold to retailers and the price for eggs used for export. E.g. if 96 percent of the eggs are sold to retailers, 4 percent of the eggs receive a reduced price corresponding to the export price.

If the eggs from a flock of hens cannot be used as consumer eggs, Danæg tries to use the eggs for another purpose. The payment is determined according to the use and sales price.

Danæg is entitled to pay a reduced price of DKr 0.35 for eggs from hens older than 76 weeks.

The producer receives a reduced price for eggs from hens in excess of the contracted number of hens. The reduced price is equal to the price of imported eggs.

The producer is compensated when Danæg requires a part of the flock to be slaughtered in order to reduce the total supply.

DKK 0.0047 per egg is paid into a personal equity account, which is paid out on legal termination of membership.

Example of a payment[26]

The producer delivered 18,000 deep litter eggs.

	Quantity	Price DKr/egg	Payment
First-rate eggs			
- XL	565	0.40	226.00
- L	10,829	0.74	8,013.46
- M	5,517	0.69	3,806.73
- S	51	0.26	13.26
Sub total	16.962		12,059.45
Eggs sorted out by Danæg			
- Cracked eggs	660	0.10	66.00
- Dirty eggs	119	0.10	11.90
Eggs with blood	12	-0.08	-0.96
Discarded eggs	157	-0.08	-12.56
Sub total	948		64.38
Eggs sorted out by producer			
- Cracked eggs	90	0.20	18.00
Sub total	90		18.00
Various			
Personal equity account	18,000	-0.0047	-84.60
Export price reduction (4% of delivery)	654	-0.18	-117.69
Quantity reduction	18,000	-0.0020	-36.00
Sub total			-238.29
Total payment			**11,903.54**

Table 6.4.5 The payment to an egg producer

Risk and insurance

General production risk

The producers bear most of the general production risk directly through the standard payment. However, the payment scheme for different egg types and sizes enables

[26] The example is based on an actual payment between Danæg and a producer (Danæg, 2001b).

Danæg to transfer some risk between producer groups. Furthermore, the equity in the cooperative can be used as a buffer to absorb some of the deviation in profits and production from year to year.

Specific production risk
Specific production risk is primarily borne by the individual producer through the standard payment. However, the payment scheme enables Danæg to over compensate producers with flocks of hens struck by salmonella or producers with relatively small eggs and thus provide risk sharing.

Price risk
The price risk is primarily borne by the individual producer through the standard payment. The possibilities of risk-sharing between the producer groups or using the equity as a buffer as mentioned above also apply with respect to price risk.

6.5 Broilers for Rose Poultry Ltd

6.5.1 The processor

Core business
Rose Poultry Ltd[27] slaughters, processes, and sells poultry products.

Contracts
Rose Poultry uses a standard 5-year contract and a contract for producers with new hen-houses.

Size
Rose Poultry has a turnover of DKK 1.1 billion and has 900 employees (1999). Rose Poultry has a market share of approximately 40 percent of Danish production. Four investor-owned poultry slaughterhouses dominate the Danish production of broilers, see Table 1.

Slaughterhouse	Market share in percent
Rose Poultry	40%
Danpo	40%
Padborg	10%
Struer	10%

Table 6.5.1 Market shares for poultry slaughterhouses[28]

The industry exports 65 percent of its production.

Ownership
Rose Poultry is a limited liability company formed by a merger in 1999. The main shareholders are the Pedersen Family (54%) and the Løth Family (36%); Hedegård Ltd, which is quoted on the Copenhagen Stock Exchange, owns the remaining 10%. After the merger in 1999 of Skovsgaard Fjerkræslagteri (Skovsgaard Poultry Slaughterhouse) and Vinderup Poultry, the company continued under the name of Rose Poultry. Both of the merging companies have existed for more than 40 years.

[27] The primary sources for this fact sheet are: Rose Poultry (2000a-d).
[28] The Danish Competition Council (2000).

6.5.2 The producers

Total production
Approximately 110 producers deliver broilers to Rose Poultry. The producers use around 300 hen-houses for their production. The total production is 57 million broilers, which corresponds to an average production of approximately 520,000 broilers per producer per year. The average production of broilers per hen-house per year is approximately 190,000.

Specialization
Broiler production is the primary source of income for the producers. Broiler production is typically supplemented with arable production. The average producer's revenue from selling the broilers is approximately DKr 4.5-5 million[29].

6.5.3 Production and processing

Day-old chicks (weighing approximately 50 grams) are put in cleaned and heated hen-houses with new bedding. Approximately 6 weeks later the broilers are slaughtered at a weight of 2000-2200 gram.

A large part of the broilers is produced in new and modern hen-houses. The quality of the hen-houses is important for avoiding salmonella and campylobactor problems. The production is highly automated. Computers control feeding and ventilation in most hen-houses.

Rose Poultry follows the program for eliminating salmonella laid down by Fødevaredirektoratet (The Veterinary and Foods Department). The program contains rules about where the day-old chicks can be bought, what feed can be used, how to clean the hen-houses and feeding installations as well as inspections during the breeding period and after slaughtering.

6.5.4 Contract details

Selection of producers
There is open access to contract production for Rose Poultry.

Duration
Contracts are made for at least a 5-year period, but they can be terminated on 2 year's notice. Contracts for producers with new hen-houses have no time limit, but have a 1-year notice of termination.

[29] Average production per producer: 520,000 broilers. Weight at slaughtering 2.0-2.2 kg. Settlement price December 2000 DKK 4.4 per kg. plus quality bonus.

The processor's tasks

- Buy the contracted quantity of broilers from the producers.
- Determine the age of the broilers at slaughter and the time of slaughter. The aim is an average weight between 1,750 and 2,200 gram. Rose Poultry and the producers work together on this.
- Collect and transport the broilers.
- Process the broilers.
- Sell the products.

The Producer's tasks

- Buy day-old chicks from a supplier approved by Rose Poultry.
- Buy feed from a supplier approved by Rose Poultry.
- Supply the contracted quantity of broilers to Rose Poultry (approximately every 8th week). The producer can only halt the production (e.g. to do necessary repairs) if Rose Poultry approves, i.e. at a time acceptable to Rose Poultry.
- Observe the plan of action on salmonella laid down by Fødevaredirektoratet (The Veterinary and Foods Department).
- Build hen-houses, maintain and improve the production facilities.

Enforcement and monitoring

The production is not monitored. An arbitrator settles disputes about the contract.

Payment

Standard 5-year contract

Rose Poultry determines the price for broilers. The price is determined through a trade-off between the company's current profit and the need to maintain and attract producers in the long-run through competitive prices. Until 2000, the four private Danish poultry slaughterhouses together determined the price, but The Danish Competition Council has prohibited this practice[30]. In addition to the standard price various bonuses are paid. The bonuses are[31]:

- Contract bonus (DKr 0.15 per kg).
- Salmonella bonus (DKr 0.07 per kg. broiler free of salmonella).
- Campylobactor bonus (DKr 0.05 per kg. broiler free of campylobactor).
- Quality bonus (DKr 0.08 per kg. broiler without feed remains).

Producers are not paid for feed remains in the broilers. The feed remains are weighed and deducted from the weight of the broilers at delivery.

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[30] The Danish Competition Council (2000).
[31] Rose Poultry (2000c).

Contract for producers with New hen-houses

The producers under a "Contract for Producers with New Chicken Houses" are paid the same standard price and bonuses as the producers with 5-year contracts. In addition the "Contract for Producers with New Chicken Houses" contains a new hen-house bonus of:

Year	Bonus, DKr per kg. (live weight)
1 & 2	0.20
3 & 4	0.15
5	0.10
6	0.05

Table 6.5.2 New hen-house bonus[32]

Example of a payment[33]

26,021 broilers were delivered. Rose Poultry estimated that, because of feed remains, one half of the broilers did not qualify for the quality bonus. Therefore the quality bonus was reduced from DKr 0.08 to DKr 0.04 per kg. delivered. The contract did not include a salmonella bonus.

	Number of Broilers	Kg	Price per kg	Total
Delivered broilers	26,021	58,010		
Discarded broilers (small, sick, dead, etc.)	298	639		
Feed deduction		519		
Accepted kg		54,652	4.16	227,352.32
Quality bonus		54,652	0.04	2,186.07
Contract bonus		54,652	0.15	8,197.78
New buildings bonus		54,652	0.20	10,930.40
Campylobacter bonus		54,652	0.05	2,732.60
Total payment				**252,029.17**

Table 6.5.3 The payment to a broiler producer

32 Rose Poultry (2000b).

33 The example is based on an actual payment between Rose Poultry and a producer (Rose Poultry, 2000d).

Risk and insurance

General production risk
The general production risk is borne by the producers. The quality bonuses shift a part of the risk related to the quality of the broilers from Rose Poultry to the producers.

Specific production risk
If the production fails for a single producer, he bears the loss himself. However, the contract includes insurance. It covers the producer in case of a failure in the ventilation system and heat stroke, if the producer has otherwise fulfilled the insurance conditions.

Price risk
The price risk is primarily borne by Rose Poultry. However, Rose Poultry determines the settlement price. This enables Rose Poultry to transfer at least a part of the price risk to the producers.

Other risk
Rose Poultry bears the risk of fluctuations in demand since Rose Poultry guarantees to buy the contracted quantity of broilers.

6.6 Fruit for Vallø Saft A/S

6.6.1 The processor

Core business
Vallø Saft A/S processes fruit and berries and sells semi-manufactured products such as concentrate, purée, and juice. The company has no retail sales[34].

Contracts
A standard contract is used. It covers approximately 60 percent of the berries bought by Vallø Saft in Denmark. The rest of the Danish berries are bought through two producer associations or through private dealers.

Size
Vallø Saft has a turnover of approximately DKr 240 mill. (2000) and has about 50 employees in Denmark and 35 employees in Poland.

Vallø Saft processes approximately 65 percent of the Danish production of berries. The remaining Danish berries are processed into jelly or deep frozen by other Danish companies.

Around 70 percent of the berries used in Vallø Saft's production are imported, primarily from Poland. The company exports around 90 percent of its production. Semi-manufactured products are sold on the world market, where Vallø Saft's ability to affect the price is very limited.

Ownership
Vallø Saft A/S was originally privately owned, but later the ownership was dispersed. Currently 33% of the stock is held by the family trust fund ”Lisa and Gudmund Jørgensens Fond”, 33% by ”Udviklingsselskabet Argo A/S” and 16,67% by ”A/S Erhvervsinvestering af 3/9 1983”.

6.6.2 The producers

Total production
76 producers are under contract and 22 producers sell directly to Vallø Saft without contract. In addition Vallø Saft buys fruit through producer associations and private dealers.

The total area used for cherries and blackcurrants in Denmark is approximately 3,800 hectares. Vallø has contracts covering 1,000 hectares and buys fruit grown on

[34] The primary sources for this fact sheet are: Vallø Saft (1999, 2000), and Jes Bjerregaard, Mogens Christensen and Hardy Hollerup Mikkelsen (1999).

700 hectares from producers without contracts. In addition, Vallø Saft buys the fruit grown on approximately 900 hectares through producer associations and private dealers. The average areas are approximately 13 hectares for producers with contracts and 30 hectares for producers without contracts[35].

Specialization
Many producers of berries have produced berries for a long time and are used to wide price fluctuations. Typically, the producers of berries have other sources of income. The producers normally diversify their farm production and often have off-farm income.

6.6.3 Production and processing

The production has a long time horizon as illustrated in Table 1 below:

Type of fruit	First harvest	Last harvest
Cherry	Year 6	Year 20-25
Blackcurrant	Year 2	Year 6

Table 6.6.1 Time horizon in the production of fruit[36]

The fruit is machine-harvested. All the Danish berries are harvested within a 6-week period. Once harvested, the berries must be processed or frozen within 3 days in order to remain fresh. Sometimes the factory faces capacity constraints during peak periods.

6.6.4 Contract details

Selection of producers
All interested producers can, in principle, enter a contract with Vallø Saft for fruit production. However the producers have to comply with Vallø Saft's quality control standards (e.g. requirements about size).

Duration
The duration of the contractual relationship is determined individually for each contract. The duration of standard contracts is 1 to 5 years.

The processor's tasks
- Buy the entire harvest.

[35] Mogens Christensen, Supply Manager Vallø Saft, personal communication, Vallø, 2000.
[36] Jes Bjerregaard, Mogens Christensen and Hardy Hollerup Mikkelsen (1999).

- Provide advice.
- Forecast the expected time of harvest and the yield of the individual producers (together with the producer) taking into account the production capacity at Vallø Saft. The forecast is used to plan the harvest.
- Transport the fruit (at the expense of the producer).
- Measure the content of dry/solid matter (Brix).
- Process the fruit.
- Store the products (incl. financing).
- Sell the products.

The producer's tasks

- Plant the trees/bushes.
- do all crop work (this includes following the legislation on the use of pesticides etc.).
- On demand, show the log of chemical plant protection.
- Work out a forecast for the time of harvest and the yield (together with Vallø Saft).
- Harvest the fruit.
- Deliver the entire harvest right after harvesting (in cooperation with Vallø Saft so that delivery is done quickly, efficiently and at the arranged delivery time).

Enforcement and monitoring

At least once during the growing season, a specialist from Vallø Saft visits the producer to discuss quantity, quality, and the timing of the harvest.

An arbitrator settles disputes arising out of the contract.

Payment

Producers are paid the European market price. Berries of average Brix, i.e. the year's average content of solid matter in the berries bought by Vallø Saft, are paid for at the market price. Deviations from the average Brix lead to a bonus/deduction in the price. Vallø Saft uses a relative performance evaluation scheme whereby producers who deliver high quality berries are rewarded. For each percentage point by which the Brix content is above (or below) the standard Brix content, the price is increased (or reduced) by 0.5 percent. The standard Brix content is calculated as the average Brix content of the entire harvest.

Examples of payments

The berries delivered are above *standard quality:*

		Payment in DKr
52,317 kg. of berries of DKr 7.00 per kg		366,219.00
Quality adjustment		
Delivery on average	19.5 Brix	
Standard of the year	18.2 Brix	
Brix deviation in percent	7.12%	
Brix adjustment	3.57%	13,079.25
Total		**379,298.25**

Table 6.6.2 Example of a payment for berries of above average standard[37]

The berries delivered are below standard quality:

		Payment in DKr
52,317 kg. of berries of DKr 7.00 per kg		366,219.00
Quality adjustment		
Delivery on average	16.9 Brix	
Standard of the year	18.2 Brix	
Brix deviation in percent	-7.12%	
Brix adjustment	-3.57%	-13,079.25
Total		**353,139.75**

Table 6.6.3 Example of a payment for berries of below average standard[38]

Risk and insurance

General production risk

The producers are protected against the risk of general fluctuations in quality, since Vallø Saft's total payment to the producers only depends on the quantity of the harvest and the market price, but not on the average quality of the Danish berries. By paying the market price Vallø Saft bears the risk of a general fall in the quality of the Danish harvest (the market price depends on the quality of the berries on the

[37] Vallø Saft (1999).
[38] Vallø Saft (1999).

European market which often differs from the quality of the Danish berries). A generally low quality of the berries bought through contracts only affects the earnings of Vallø Saft. This is because the price Vallø Saft can obtain depends on the acidity and Brix content, i.e. the quality is crucial for the price achieved for the berries.

The general production risk regarding quantity is borne by the producers. An unsuccessful harvest also affects earnings of Vallø Saft because of under utilization of the production capacity.

Specific production risk
If the individual producer has an unsuccessful harvest, the producer bears the loss himself. The individual producer also bears part of the risk related to the quality of the berries due to the bonus or deduction in the payment price.

Price risk
The price risk is borne by the producers, since the producers are paid the market price.

Other risk
Vallø Saft bears the risk of fluctuations in demand because the company guarantees the market price for the entire production of the producer. Vallø Saft also bears the risk related to capacity constraints at the factory.

6.7 Grass and Clover

This fact sheet describes the contracts in the Danish grass and clover seed industry. Three firms dominate the industry: DLF-Trifolium Ltd, Hunsballe Ltd, and Wiboltt Ltd.

6.7.1 The processors

Core business

The firms DLF-Trifolium, Hunsballe and Wiboltt[39] buy and sell (domestically and internationally) seeds for gardening and farming within a broad spectrum of species such as clover and forage grass, amenity grass, pulse seeds and industrial crops.

Contracts

Each firm uses a standard contract for clover and grass seed production. The contracts are very similar for each of the three firms. One of the firms uses a similar contract for rape seed, linseed, white mustard, poppy, caraway etc.

There are two main approaches for determining payment. The traditional approach, used by DLF-Trifolium and Hunsballe, is a commission contract. The quality group approach used by Wiboltt divides the deliveries into different quality classes and the settlement price is determined individually for each quality class.

Size

DLF-Trifolium is the world's largest producer of clover and grass seed. The firm has a turnover of DKr 751 mill. and has approximately 340 employees (1999). The firm has a market share of approximately 33 percent of the sales of seed within the EC. The firm contracts for approximately 75 percent of the area used in the production of grass and clover seed in Denmark.

Hunsballe has a turnover of DKr 85 mill. and approximately 35 employees (1999). The firm has a market share of the sales Denmark of approximately 33 percent. The firm contracts for approximately 12 percent of the area used for production of grass and clover seed in Denmark.

Wiboltt has a turnover of DKr 80 mill. (1999). The firm contracts for approximately 12 percent of the area used for production of grass and clover seed in Denmark. Wiboltt sells its products through Cebeco Royal Group.

The industry exports 85-90 percent of its production.

Ownership

DLF-Trifolium is a joint-stock company controlled by the 3800 members of the cooperative DLF AmbA.

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[39] The primary sources for this fact sheet are: Bjarne Sørensen and Aksel Nissen (1999), DLF-Trifolium (1998, 2000), Hunsballe (1996, 2000), Steen Kisselhegn (1999), and Wiboltt (2000a,b).

Hunsballe is a private firm primarily owned by different trust funds. The largest shareholder is Idagård Fonden (65 percent). The rules of this trust limit the possibilities for taking profits from Hunsballe. This means that Hunsballe in practice operates as a non-profit firm (like a cooperative).

Wiboltt is 100 percent owned by the Dutch firm Cebeco Royal Group.

6.7.2 The producers

Total production

There are approximately 5000 producers of grass and clover seed in Denmark. The total area used for the production of grass and clover seed is approximately 80.000 hectares. The average is 16 hectares per producer.

Specialization

There are large benefits from specialization and experience is very important. Therefore the producers typically specialize in one particular type, e.g. white clover. The share of a producer's income from seed production is typically 5 percent. For some producers the share is up to 20 percent.

6.7.3 Production and processing

The production of seed follows the timetable below:

- Year 0: wheat and grass seed sown
- Year 1: harvest of wheat
- Year 2: harvest of grass seed
- Year 3: possible harvest of grass seed
- Year 4: possible harvest of grass seed

Production of seed is more risky than other crops. The differences in yields from year to year often vary by as much as 20-30 percent. Also, there are wide price fluctuations, e.g. the price of rye grass was DKr 8 per kg. in 1997 and DKr 5 per kg. in 1999.

6.7.4 Contracts details

Selection of producers

To ensure that the producers receive reasonable payment, all firms control supplies by limiting the entry to contract production. The contracts are first offered to the current producers and next to producers, whom the firms' consultants believe to be competent plant producers.

Duration

The duration of the individual contractual relationship depends on the growing conditions of the specific variety. For most varieties, the seeds are sown in wheat in year 0, wheat is harvested in year 1, and the seeds are harvested in year 2 and maybe the following years if the price outlook is favorable. In practice, the contractual relationships last longer. The producers are normally offered renewal of their contracts. Furthermore, the producers achieve relatively larger gains by their production specialization.

The processor's tasks

- Deliver the sowing seeds.
- Determine whether the fields should be re-ploughed (only the DLF-Trifolium has this option in its contract).
- Inspect the production areas and provide advice.
- Transport the harvested seeds.
- Process the seeds.
- Sell the seeds.

The producer's tasks

- Supply production areas.
- Fulfill the certification requirements of the Plants Directorate of the Department of Agriculture.
- Do the sowing.
- Do all crop work until harvest.
- Harvest the seeds.

Enforcement and monitoring

Consultants (either the processor's own consultants or consultants appointed by *Plantedirektoratet*, Plants Directorate) certify the areas according to the specifications of the Plants Directorate. The Plants Directorate makes spot checks and analyzes the test samples (15 percent of the areas). This field monitoring helps assessment of the quality of the finished product, since the qualities of seeds are more easily seen in the standing crops than in the final product.

Upon delivery, the processor takes a sample of the production for possible test screening. If the producer wants the processor's test checked, the Plants Directory will perform a new test.

An arbitrator settles disputes arising out of the contract.

Payment

The companies use different methods for determining payment. The traditional method, the commission system, is as follows. The quality sample is used for converting the delivered quantity into a standard quality. In the conversion to standard quality, the delivered quantity is corrected for cleansing, purity (other varieties of seeds and other foreign elements) and germination capacity. For each species, the company adds up the sales revenue and subtracts the costs directly related to the sale. This results in a gross revenue from which a commission is deducted. Using the resulting net revenue, an average price is calculated for each species. Traditionally, the commission is 18 per cent for all species. However, one of the private companies changes the commission from year to year. The calculation of the average price (used as the settlement price) is based on the companies' private information about the sales revenues and costs directly related to the sale. The individual producer cannot obtain this information.

One of the private firms has a different approach; it uses quality groups[40]. The deliveries are divided into different quality groups according to:

- Content of seeds from certain unwanted species (e.g. couch grass).
- Purity.
- Germination capacity.

The producers are guaranteed a minimum price for the first harvest year. In two-year contracts the minimum price for the second harvest year can be determined one year in advance. The contract does not specify how the settlement price is determined. The company determines the price once the seed is sold. The price is determined by a trade-off between the current profits of the company and the need to attract producers in the long term through a competitive settlement price. There are transfers of sales revenues between the different groups if one group achieves low yields. There are no formal rules for this transfer, but the transfer is determined by the objective of providing competitive settlement prices for all groups.

[40] There is no conversion to standard quality.

Example of a payment[41]

A quantity of 10,000 kg. cleaned ordinary rye grass seed was delivered
The settlement price for standard quality is 5.00 DKr/kg

The basic standard for ordinary rye grass according to the seed contract:

Seed of other species (weed and unwanted seeds of cultivated plants)		1.0%
Pure seed germinated		93.0%
Actual delivery		
Pure seed		99.3%
Weed		0.0%
Unfamiliar seeds of cultivated plants		0.0%
Germination capacity		95.0%
Producer's payment		
Purity after correction	$99.3\% + 5 \bullet (0.1 - 0.0)\%$	99.8%
Pure seed germinated	$99.8\% \times 95\%$	94.81%
Producer's settlement price[42]	$\frac{94.81\%}{93\%} \times 5.00$ DKK per kg	5.10 DKr per kg
Settlement amount	**10,000 kg. x DKr 5.10 per kg**	**DKr 51,000**

Table 6.7.1 Example of a payment to a producer in the ordinary commission system

Risk and insurance

General production risk

The general production risk (e.g. poor harvest as a result of bad weather) is primarily borne by the producers. A poor harvest also affects the processor's earnings through low utilization of production capacity and lower profit on sales (18 percent of the fall in gross revenue if the company charges a fixed commission). When the settlement is based on the commission system, there is no risk sharing between the producers of different species, neither regarding production nor price risk.

When payment is determined according to quality groups, there is risk sharing between producers of different species. However, to attract producers the company

[41] DLF-Trifolium (1998).

[42] $$\frac{[\%\text{ pure seed} + 5(\%\text{ basic standard} - \%\text{ unfamiliar seeds of cultivated plants})] \times \text{germination capacity}}{\text{basic standard pure seed germinated}} \times \text{settling price for standard quality}$$

using quality groups must match the prices paid by other seed companies, i.e. the commission system works as a benchmark for the settlement prices.

Specific production risk

If the production fails for an individual producer, he must bear the loss himself.

Price risk

Producers bear the price risk in the ratio of 82:18 in the commission system. In practice, the price risk sharing is similar for the company paying according to quality groups, since the commission system works as a benchmark for the settlement prices.

Other risks

In the commission system, the seed companies bear part of the risk related to the marketing, because companies determine the prices for unsold quantities before the payment is settled.

Seed production is very dependent on subsidies from the EC. There is considerable institutional risk from changes in the Common Agricultural Policy. According to the contracts, the producers bear this risk.

6.8 Sugar Beet for Danisco Sugar A/S

6.8.1 The processors

Core business
Danisco Sugar[43] supplies industrial consumers (80% of sales) and household consumers (20% of sales) with a wide range of sugars and syrups, as well as molasses for animal feed and other products extracted from sugar beet.

Contracts
The 5-year general contract between Danisco Sugar and DKS (*Danske Sukkerroedyrkere* – the Beet Growers' Association) determines the administration of the EC sugar regulation.

The EC sugar regulation guarantees the producers a high intervention price through the use of production quotas, import tariffs, and export subsidies. The EC sugar regulation fixes a production quota for each country. The quota is in two parts: A-sugar (consumption needs) and B-sugar (safety margin). A-sugar is paid for at 98 percent of the intervention price. B-sugar is paid for at the intervention price minus 39.5 percent levy[44]. Sugar production in excess of the A+B quotas is called C-sugar. C-sugar must be sold on the world market (i.e. outside the EC) without a subsidy. According to the EC sugar regulation, the processor must pay the producers 60 percent of the intervention price on white sugar (A and B-sugar). For C-sugar the producer is paid 60 percent of the average sales value of exported sugar, calculated as the sales price less all costs.

The country quotas for A- and B- sugar are divided between the producers, i.e. each producer is allocated part of the country's quota. The producers sign a production contract for A- and B-sugar each year.

Size
Danisco Sugar is the fourth largest sugar producer in Europe. Production and processing takes place in Denmark, Sweden, Finland, Germany, and Lithuania. The company has a turnover of DKr 8.0 billion (1999/2000) and has approximately 4,000 employees. Danisco Sugar has a total EC sugar quota of 1.1 million tons per year, representing approximately 7 percent of the total EC quota. Danisco Sugar has contracts covering 100 percent of the Danish sugar quota of approximately 0.4 million tons of A-sugar and 0.1 million tons of B-sugar.

[43] The primary sources for this fact sheet are: Danisco (2001), DKS (2000), DKS and Danisco Sugar (1996) and Klaus Sørensen (1999).
[44] The levy is used to finance export subsidies.

Ownership

Danisco Sugar is a subsidiary company, 100 percent owned by Danisco A/S. The largest shareholders in Danisco A/S are three pension funds (ATP, PFA Pension, and LD) owning about 25 percent of the shares in Danisco A/S.

6.8.2 The producers

Total production

There are approximately 15,000 producers delivering beet to Danisco Sugar (in all countries). The total sugar production of Danisco Sugar is approximately 1.47 million tons (2000/2001). Approximately 25 percent of the sugar is C-sugar[45].

In Denmark approximately 6,400 producers deliver 3.2 million tons of cleaned beet (2000/2001). When processed this amounts to 0.53 million tons of white sugar. The Danish producers use approximately 58,600 hectares for sugar beet production. Thus, on average each producer uses 9.2 hectares for sugar beet production.

Specialization

The production of sugar beet is a part of the producers' crop rotation. The producers can at the most use 35 percent of their acreage for sugar beet (determined in the general contract). In addition to arable production some producers have an animal production.

6.8.3 The production and processing

The sugar beet need water, warmth and light to produce sugar. The production of beet follows the timetable below:

- The beet seed is sown at the beginning or middle of April.
- The beet campaign (i.e. delivery and processing of sugar beet) runs from the middle of September to the end of the year. The harvesting season ends before the beet campaign ends, so the producers may have to store the beet in clamps.

In 1999 the number of processing factories was reduced from 4 to 3, because the factory in Gørlev closed. Danisco Sugar ran a program (1996/1997 to 1998/1999) for transferring individual quotas to producers delivering to the factory in Assens. Danisco Sugar pays DKr 20 million to the program for transferring 30,000 tons of individual quota. Producers selling quota are paid DKr 1,500 per ton of raw-sugar. Producers buying quota for delivery in Assens pay DKr 850 per ton of raw-sugar. Also, Danisco Sugar covers additional transport costs for a two-year period (2000/2001 and 2001/2002) to producers formerly delivering to Gørlev.

[45] (1.47 million tons – 1.1. million tons)/1.47 million tons.

6.8.4 Contracts details

Selection of producers

Only members of DKS can obtain the bonuses described in this contract. Producers without membership of DKS only receive the minimum price for their beet, cf. section 6.8.4. In practice almost all producers are members of DKS.

Reduction in individual quota

A producer's individual quota is reduced if he delivers less than 92 percent of his individual quota (A+B sugar) for two years in a row. The reduction in the quota of A-sugar[46] is:

$$0.92 \cdot (\text{contracted A - sugar}) - \left(\frac{\text{contracted A - sugar}}{\text{contracted A + B - sugar}} \right) \cdot (\text{delivered quantity})$$

Danisco Sugar can choose not to reduce the individual quota if the producer informs Danisco Sugar during the growing season about problems caused by acceptable reasons, e.g. hail.

Increase in individual quota

Excess quota (i.e. quota not contracted for, either due to reductions in individual quotas or an adjustment in the total Danish quota) is offered to existing producers and, if necessary, to new producers. The excess quantity can temporarily[47] be contracted as extra B-sugar deliveries to Assens Sukkerfabrik (Assens Sugar Factory) to ensure a more efficient use of the production facilities. The final allocation of the excess contract quota is made in proportion to the existing distribution in the contracts. For both temporary and final allocation, producers requesting additional individual quota must fulfil the following requirements:

- The area used for beet production must be below 35 percent of the producer's total cultivation area.
- The delivery percentage[48] may not have been below 92 percent for two years in a row during the previous 5 years.
- The delivery percentage must have been at least 100 percent on average over the previous 5 years.
- The quantity of A- and B-sugar in the production contract must be equal to the producers' individual quota.

[46] The quota on B-sugar is reduced by the same percent.
[47] I.e. during the current general contract.
[48] I.e. actual delivery in percentage of quota.

Duration

The current general contract between DKS and Danisco Sugar runs for five years. The production contracts between Danisco Sugar and the individual producers must be renewed each year.

The individual quotas are tied to the land and can only be transferred through sale or lease of the land. It is not allowed to lease individual quota alone. New owners of individual quota that has previously been under contract take over all rights and obligations towards Danisco Sugar.

Producers can suspend their quota temporarily, i.e. not sign a production contract on their entire quota. However, the suspension of individual quota is quantitatively insignificant[49].

The processor's tasks

- Choose sowing seeds together with DKS.
- Adjust the individual quotas (all quotas are adjusted in proportion to excess quota, except for deliveries to Assens).
- Deliver the sowing seeds.
- Determine (with DKS) the starting time of the beet campaign for each factory.
- Determine changes in the delivery plan, if Danisco Sugar finds it necessary in order to ensure efficient production at the factories. Danisco Sugar pays the additional transport costs when the place of delivery is changed.
- Weigh and analyze the beet. The beet are weighed and washed, and stones and other dirt are removed. On this basis the beet's purity percent is calculated. The content of raw-sugar and amino-N is also measured. These measures are used for calculating the producer's payment.
- Process the beet into sugar.
- Sell the sugar.

The producer's tasks

- Choose sowing seeds (through DKS) along with Danisco Sugar.
- Determine (through DKS) the starting time of the beet campaign for each factory.
- Supply production areas.
- Sow the beet seeds.
- All crop work until harvest.
- Participate in and pay for collective disease and vermin control and the collective monitoring programs which the parties have agreed upon.

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[49] Less than 0.2 percent of the total individual quota is temporarily suspended.

- Harvest the beet, remove the tops and store the beet in clamps.
- Deliver the beet in compliance with the delivery schedule.
- Deliver the contracted quantity of polar-sugar[50]. The beet delivered first fulfil the quota of A-sugar in the production contract, and then the quota of B-sugar in the contract. Additional deliveries are settled as C-sugar[51].
- Ensure the high quality of delivered beet. Loads of beet are rejected, if
  - the beet are damaged by frost
  - the beet have been tainted
  - the removal of the tops is poorly done
  - if there is a significant content of straw, grass, weed, rocks, dirt or the like in the load
  - if Danisco Sugar estimates that more than 5% of the beet are rotten
- Fill out and ensure that a plant passport is attached to each load (required by law). The plant passport contains relevant information to identify the load.
- Transport – deliver to the factory (except for producers who used to deliver to the factory in Gørlev).
- Sell pulp from the processing of sugar. The producers can buy pulp back at the same price and use the pulp as feed in their animal production.

If a producer is in serious breach of the contract, Danisco Sugar can refuse future contracts with the farm and/or the owner concerned.

Enforcement and monitoring

Danisco Sugar is entitled to inspect the fields. The producer can, at his own expense, have the analysis of his deliveries (e.g. the sugar content) checked at an independent laboratory. An arbitrator settles disputes arising out of the contract.

Payment

The producers are paid for the quantity of beet delivered. The basic payments to the producers are determined by the EC sugar regulation. There are different prices for A-, B-, and C-sugar beet. Danisco Sugar pays a special bonus for deliveries of between 92 and 98 percent of the individual quota, B_2 beet[52]. The prices are illustrated in Table 1 below.

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[50] Polar sugar is the sugar content in the beet.

[51] After delivery the amount of raw-sugar is calculated for each producer. This amount is adjusted by the ratio between the amount of white sugar processed and the amount of raw-sugar delivered. The adjusted quantity of raw-sugar delivered is used to calculate the distribution of A-, B-, and C-sugar beet.

[52] It is required that a production contract for the full B-sugar beet quota shall have been signed.

Sugar Beet	Payment	Payment in 1999/2000, DKr per ton of beet
A	EC minimum payment minus 2 percent levy	348
B	EC minimum payment minus 39.5 percent levy	215
B_2	EC minimum payment minus 39.5 percent levy plus DKr 64.20.	279
C	World market price. The producers' share is 60 percent of the average sales value of export sugar calculated as the sales price less all costs.	110

Table 6.8.1 Basic payments to producer[53]

In addition to the basic payments Danisco Sugar uses the following incentive payments:

Sugar percentage

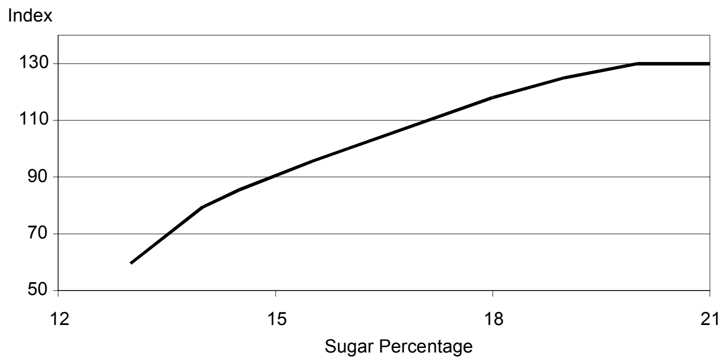

Figure 6.8.1 Addition or reduction in payment for sugar percentage

Amino-N Numbers

Average Amino-N Number	DKr per ton clean A- and B-Sugar Beet
141 and above	0.00
131-140	1.50
121-130	2.75
111-120	4.50
101-110	6.50
91-100	7.50
90 and below	8.00

Table 6.8.2 Additional payment for Amino- N[54]

53 DKS (2000).
54 DKS and Danisco Sugar (1996).

Clean delivery

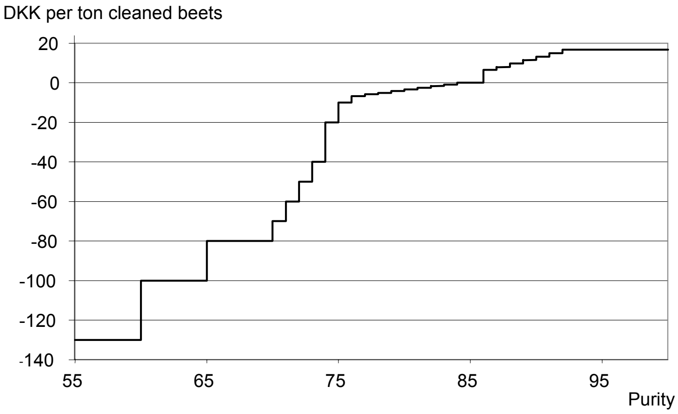

Figure 6.8.2 Addition or reduction in payment for clean beet

The payment for product purity (clean delivery) to each farmer is reduced proportionally if the total payment for clean beet exceeds DKr 24 million.

Early and late Delivery
Producers receive an additional payment for A- and B-sugar beet delivered before 1st of October. The additional payment is 1 percent of the intervention price for each day by which the delivery is made before the 1st of October.

Producers receive an additional payment for beet delivered after the 13th of December as shown in table 3 below. The additional payment is determined as percentage of the EC minimum payment.

	A- and B-Sugar Beet	C-Sugar Beet
14.12-16.12	1%	0.6%
17.12-19.12	2%	1.2%
20.12-22.12	3%	1.8%
23.12-25.12	4%	2.4%
26.12-	5%	3.0%

Table 6.8.3 Additional payment for late delivery[54]

Example of a payment

Payment to a producer with a total delivery of 500 tons.

Beet	Quantity in tons	Payment in DKr per ton	Total in DKr
A	270	347.77	93,897.90
B	80	214.68	17,174.40
C	150	110.47	16,570.50
Basic payment			127,642.80
Extra payments			
- Sugar content (17%)	9% x 127,642.80		11,487.85
- B_2	64.20 x 6% x (270 tons +80 tons)		1,348.20
- Amino-N number (92)	7,5 x 350 tons		2,625.00
- Clean beet (87.5)	DKr/t 8 x 500 tons		4,000.00
- Late delivery, C (40 tons 27.12)	3% x 347.77 x 40 tons		417.32
- Late delivery, A+B (20 tons 23.12)	4% x 347.77 x 20 tons		278.22
- Early delivery (36 tons 26.09)	5% x 347.77 x 36 tons		625.99
Basic Payment in total			20,782.58
Total			**148,425.38**

Table 6.8.4 Example of a payment to a producer[55]

Risk and insurance

General production risk

General production risk is primarily borne by the producer. However, Danisco Sugar also bears some of the risk from lower production.

Specific production risk

Specific production risk is primarily borne by the producer. Danisco Sugar also bears some of the risk through its profit.

Price risk

The price risk is reduced by the EC Common Agricultural Policy. Therefore there is no price risk on A- and B sugar beet. Price risk on the C-sugar beet is shared in the ratio 60:40 between the producer and the processor.

Other risk

There an institutional risk of changes in the EC Common Agricultural Policy.

[55] The example is constructed using data for the average producer in 1999/2000, see DKS (2000).

6.9 Potatoes for AKV Langholt

6.9.1 The processor

Core business
AKV Langholt[56] processes potatoes into potato starch for use in the paper and cardboard industry. The sales are handled in a 50/50 joint venture between Cerestar and AKV Langholt.

Contracts
All members of the cooperative have fixed-quantity contracts, i.e. each member has a right and an obligation to deliver a fixed quantity each year. The board of directors can change the total contracted quantity by adjusting the quantity in all contracts by the same percentage.

Size
AKV Langholt has a turnover of approximately DKr 130 million and has around 55 employees.

AKV Langholt is one of Denmark's four potato starch factories. The production of potato starch is regulated by the EC. Every factory has a yearly quota with the possibility of using an advance of up to 5 percent of the following year's quota. AKV Langholt's quota for 2000/2001 is approximately 36,900 tons of potato starch, which is around 21 percent of the total Danish quota. More than 80 % of AKV Langholt's production is exported.

Ownership
AKV Langholt is a cooperative with approximately 300 members. Cerestar-AKV Langholt I/S is a 50/50 joint venture between Cerestar and AKV Langholt. Cerestar is a multinational company.

6.9.2 The producers

Total production
The total delivery to AKV Langholt is approximately 180,000 tons. The total area used for the production is approximately 4,500 hectares. Around 300 growers contract with AKV Langholt. Hence, on average each producer delivers 600 tons of potatoes produced on 15 hectares.

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[56] The primary sources for this fact sheet are: AKV (1991, 2000a-e, 2001a,b).

Specialization
On average the producers use approximately 20 percent of their land in the production of potatoes for AKV Langholt. Due to biological conditions it is recommended that the same field should only be used for growing potatoes each fourth year, i.e. if a producer uses more than 25 percent of his land in the production of potatoes he must base some of the production on rented land.

6.9.3 Production and processing

The production schedule is:

- Week 11-15: the seed potatoes are sown.
- Week 33: AKV offers to test for the level of starch in the potatoes.
- Week 34: trial run of the factory.
- Week 35 to 37: early campaign. Producers can apply to deliver early.
- Week 38 to 50: main campaign.

Dirt is harmful to both the quality of the starch and the production process. Clay is almost impossible to separate from the potatoes at the factory, and clay spoils the starch. Larger foreign objects frequently bring a halt to processing at the factory. On the other hand rocks and soil are not too harmful because they are easily separated from the potatoes at the factory.

6.9.4 Contract details

Selection of producers
Only producers who sign a contract are accepted as members of the AKV Langholt cooperative. The members can sell their contract (production rights) to another producer. The members can lease their contract (or part of their contract) to other members. New members must have a contract for at least 100 tons.

Duration
The contracts (membership) are continuous, but can be terminated with one year's notice. The board of directors can terminate the membership if the member breaches the contract. Payment can be changed at one day's notice.

The processor's tasks

- Advise on sowing, weed and vermin protection, and harvesting.
- Produce and sell seed potatoes.
- Test the potatoes (starch percentage).
- Receive the contracted quantity of potatoes.
- Determine the delivery plan and conditions for delivery.

- Adjust the quantity requested from the producers. (All contracts are adjusted proportionally).
- Determine the possibilities of and conditions for delivery exceeding the delivery tolerance of +/- 5%.
- If necessary, procure the missing quantity from members or non-members.
- Process and sell the product.

The producer's tasks

- Do all crop work.
- Deliver the contracted quantity of potatoes to AKV Langholt.
- Deliver potatoes containing at least 13 percent starch, otherwise AKV Langholt rejects the potatoes.
- Deliver potatoes that are healthy and fresh and without too much dirt (small rocks, soil, clay, larger foreign objects, top of the potato plant, straw, rotten and frozen potatoes). If these requirements are not met, the delivery is rejected.
- Ensure that each delivery is of the same quality and variety.
- Cooperate with other producers to arrange delivery times if preferable for the other producers.

Enforcement and monitoring

AKV Langholt takes dirt and starch test samples from the loads at delivery. There is no monitoring of the fields. A producer can raise disputes about the fulfillment of his contract at the general meeting.

Payment

The base payment for the potatoes delivered consists of the EC minimum price plus an EC subsidy. The producers receive bonuses or deductions based on specific quality criteria. There are two quality criteria for payment: dirt and starch percentage.

The percentage of dirt in the delivery affects the payment in two ways. Firstly, the producer is only paid for the net weight, i.e. the delivery minus the dirt. Secondly, there is a deduction in the payment depending on the percentage of dirt. For each incremental percentage point of dirt there is a deduction in the payment of DKr 0.5 per 100 kg. gross weight.

The higher the starch percentage, the higher is the price per 100kg. net weight delivered, up to 23% above which there is no increase in the price for a higher starch percentage, see Figure 1 below.

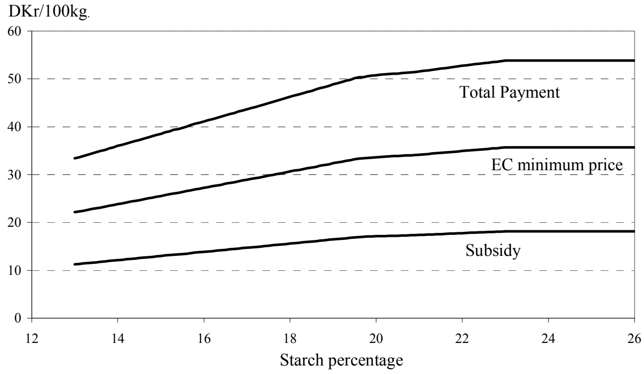

Figure 6.9.1 EC minimum price, subsidy, and total payment[57]

The higher the starch percentage, the fewer potatoes it takes to fulfill the contract. E.g. 100 kg. potatoes with 20% starch is equivalent to 116 kg. of the contracted quantity. However, there is no increase in the quantity of the contract fulfilled for starch percentages above 23, see Figure 2 below.

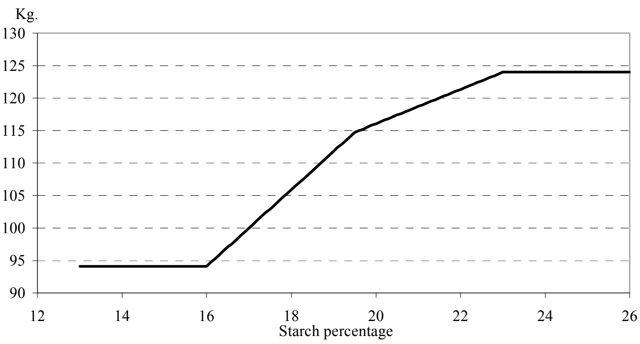

Figure 6.9.2 Contract quantity fulfilled by delivery of 100 kg. potatoes[58]

In addition to the base payment, the producers receive an after-payment at the end of the year. The after-payment for deliveries between 75 and 100 percent of the contract is twice the standard after-payment.The profit is paid as an after-payment for potatoes within the contracted quantity.

[57] This figure is based on AKV Langholt's payment scheme (AKV Langholt 2000c).
[58] This figure is based on AKV Langholt's fulfillment of contracted quantity scheme.(AKV Langholt 2000d).

Deliveries as a percentage of contracted quantity	After-payment	DKr/100kg. (2000)
< 75%	Normal After-payment	63.00
75-100%	Double After-payment	126.00
> 100%	Decided by Board of Directors	0

Table 6.9.1 After-payment

***An example of a payment*[59]**

Facts about the delivery:

Weight, 100kg	Dirt %	Net weight, 100kg	Starch %	Starch 100kg
326.20	4.00	313.16	20.0	62.632

Table 6.9.2 Facts about the delivery

Based on the 20% starch and the 4% dirt the payment is:

Payment	Quantity 100kg	Payment/100kg	Total Payment, DKr
EC min. payment	313.16	33.6383	10,534.18
EC subsidy	313.16	17.1100	5,360.44
Dirt bonus	326.20	1.0000	326.20
Total			16,220.82
Prod. fee	313.16	0.4000	125.26
Total payment			**16,095.56**

Table 6.9.3 An example of a payment

The producer fulfills[60] 363.27 100 kg. of the contracted quantity.

An example of an after-payment[61]

363.27 100kg. of starch contracted and delivered.

[59] The example is based on an actual payment between AKV Langholt and a producer (AKV Langholt, 2001e).

[60] 1.16 x 313.16 100kg

[61] The example of an after-payment is based on an actual after-payment between AKV Langholt and a producer (AKV Langholt 2001a).

After-payment	Starch, 100kg	DKr/100kg	Total
Normal (75% of contract delivery)	272.45	63.00	17,164.35
Double (25% of contract delivery)	90.82	126.00	11,443.32
Total	**363.27**		**28,607.67**

Table 6.9.4 An example of an after-payment

Risk and insurance

General production risk

AKV Langholt is a cooperative, therefore the producers bear most of the risk directly through the base payment or the after-payment. However, the equity in the cooperative can be used as a buffer to absorb some of the deviation in profits and production from year to year. This is also the case with general production risk.

Specific production risk

Specific production risk is primarily borne by the individual producer through the base payment and after-payment. There is no risk sharing for quantity deviations. However, the producers can trade potatoes internally to avoid shortfalls and excess production.

The risk of deviation in quality is primarily borne by the individual producer. In the case of low quality, the producers can deliver more potatoes within the contract quantity. This dampens the consequence of low quality.

Price risk

The price risk is transferred to the members through the after-payment. The possibilities for risk sharing mentioned above also apply with respect to price risk

Other risk

The producers bear the institutional risk of changes in the EC Common Agricultural Policy.

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